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MANAGING STORM DRAINAGE THROUGH IMPROVED LAND DESIGN

U.S. Environmental Protection Agency

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a guidance publication of the

Waccamaw Regional Planning and Development Council

Waccamaw Regional Planning and Development Council

Georgetown, South Carolina

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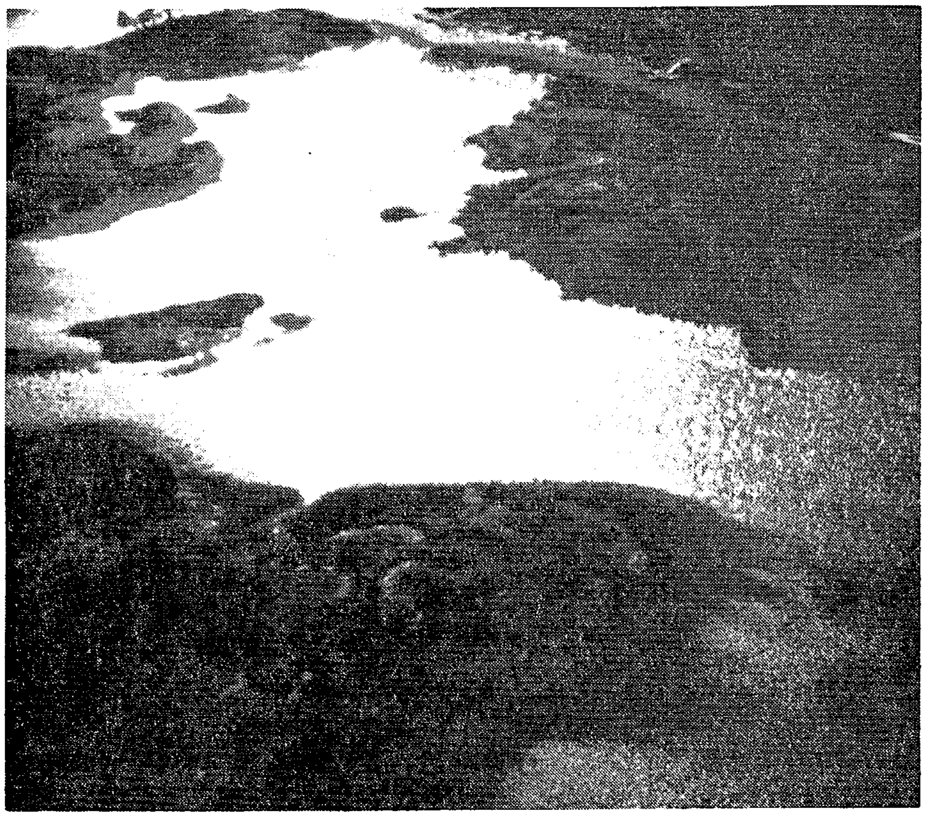
introduction

the region and its problems in brief



Drainage problems in Georgetown, Horry, and Williamsburg Counties present many constraints to farming, home building, and commercial development. Results from the Waccamaw Regional Planning and Development Council's Section 208 Nationwide Urban Runoff Program have shown overland water drainage from farm fields, residential areas, and commercial development carries pollutants into downstream wetlands, estuaries, and ocean beach surf. Problems of **drainage, flooding, erosion, and water pollution** affect both the inland areas of the three-county region and the shoreline of the Grand Strand.

Farmers, developers, homeowners, roadbuilders, and county officials are all concerned with the problems of how land drains. Because the **topography** of the region is flat and low, and because **soils** in many areas do not readily absorb rainfall, **rainwater often remains ponded on the surface or overflows drainageways, causing crop and property damage and health and safety hazards to the region's people.**

- **On the farm,** practices that lead to **erosion** of field soil and **poor ditch design** can also worsen existing drainage conditions by **silting in drainage systems and causing them to back up and overflow.**

- **Within residential areas** ditching has long been used to help speed rainfall away from homesites, as is the case with farmland, but most standard ditches cannot cure the problems of **flat homesites** on **poorly drained soils,** especially where **high water tables** exist.

- **At shopping centers and other large developments,** parking and other hard surfaces force the shedding of water too quickly into municipal **drainage systems** or onto streets, **overloading** them as well.

- **In shore areas,** too, the natural capabilities of the land to absorb rainfall are often ignored with pavements and roofs funnelling runoff onto beaches, **eroding the beach and beauty** of the Grand Strand's shoreline.

To dispose of excess water and improve soil drainage so that the land surface can be developed, swales, ditches, and canals have been excavated in order to channel precipitation more rapidly away from farm, residential, or other desirable lands. In some cases, ditches are dug deep enough to artificially lower the water table and thus render the soil above the table better drained and more usable.

But more rapid removal of surface runoff at the local level and the greater quantities of water removed through water table lowering mean a greater flow intensity and impact on downstream ditches, canals, drainage systems, and elsewhere in the area or county.

The faster it is that water flows from high elevations, the more intense are the flow impacts on downstream points within areawide drainage systems. When more water reaches an outlet point at the downstream edge of any drainage area than can be accommodated by the outlet within a given time period, the drainageways upstream of the outlet will back up and overflow, causing surface flooding on low-lying lands.

Because of the flatness of the land, many a resident of towns, subdivisions, and other communities of the region has experienced flooded floors, lawns, streets, and farmlands year in and year out, where drainage systems are incapable of overcoming the deficiencies of topography and soils.

what the handbook covers

The techniques proposed in this handbook will not solve most flooding problems caused by severe storm runoff. Nor are they intended to salvage lands that, due to poor soils, high water table, or insufficient gradient, are inherently unsuitable for development. But they can help improve drainage conditions for many sites of average soils, water table, and gradient conditions. The techniques proposed can be effective in dealing with pollution problems and the frequently occurring rainfalls of low and moderate intensity.

Of course, wetlands and high water table lands on which development cannot occur without environmental damage should be left alone. And too, good basic land design cannot cure all drainage problems.

Fortunately, there are techniques available to help improve drainage for many lands within the region, techniques that may also help reduce flow impacts on downstream areas as well as improve drainage characteristics on flat lands in various conditions.

objectives that can be attained by using this handbook

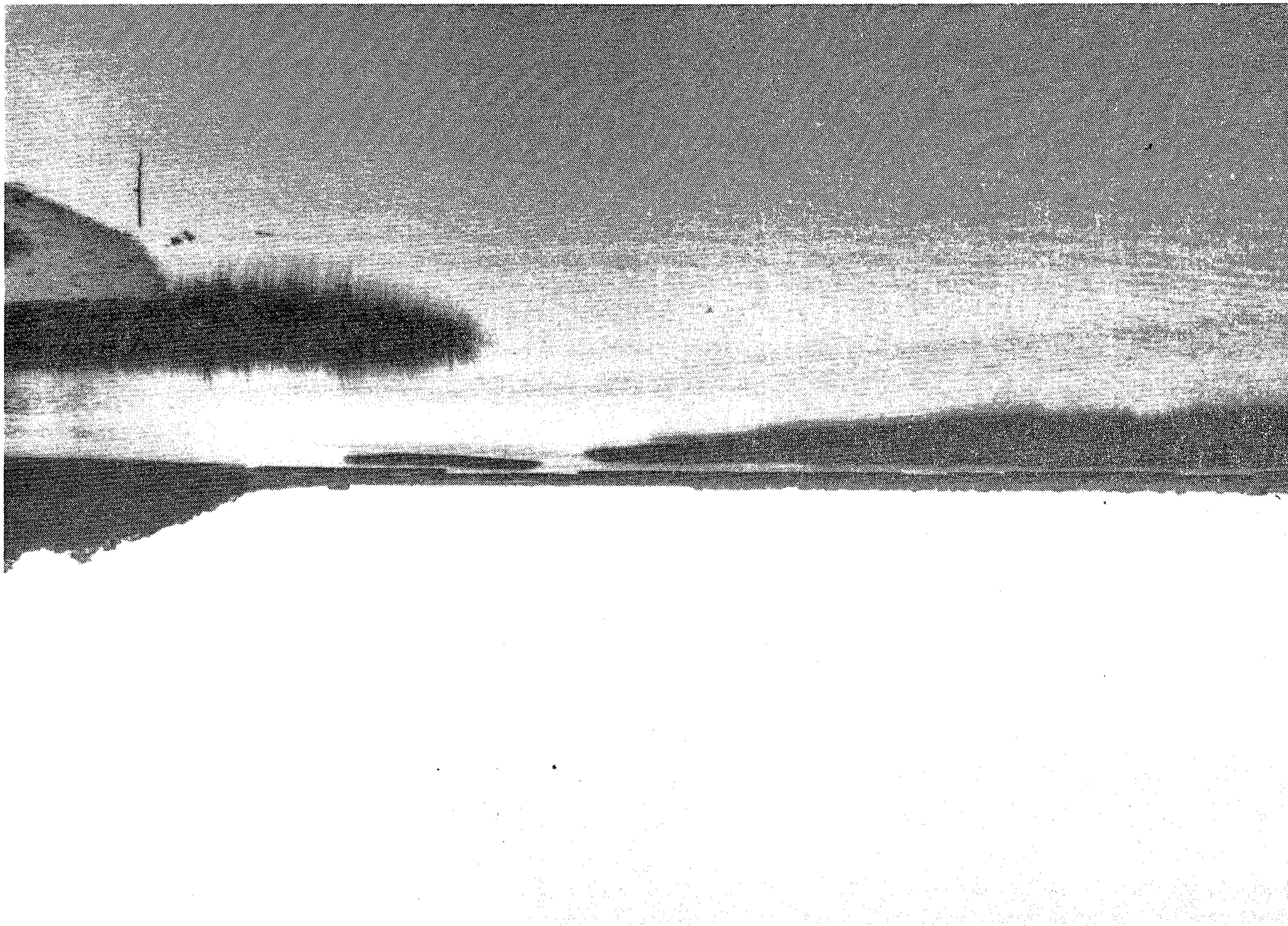
The targets that can be reached through use of this handbook to benefit homeowners, developers, farmers, commercial property owners, and the general public are:

- **Improvement of water quality**
- **Better management of on-site drainage**
- **Reduction of erosion and sedimentation**
- **Reduction of downstream flooding**
- **Enhancement of aesthetic appearance**
- **Reduction of private and public expenditures on drainage and water quality improvements**
- **Protection of wildlife habitat and the environment in general**

the next few pages . . .

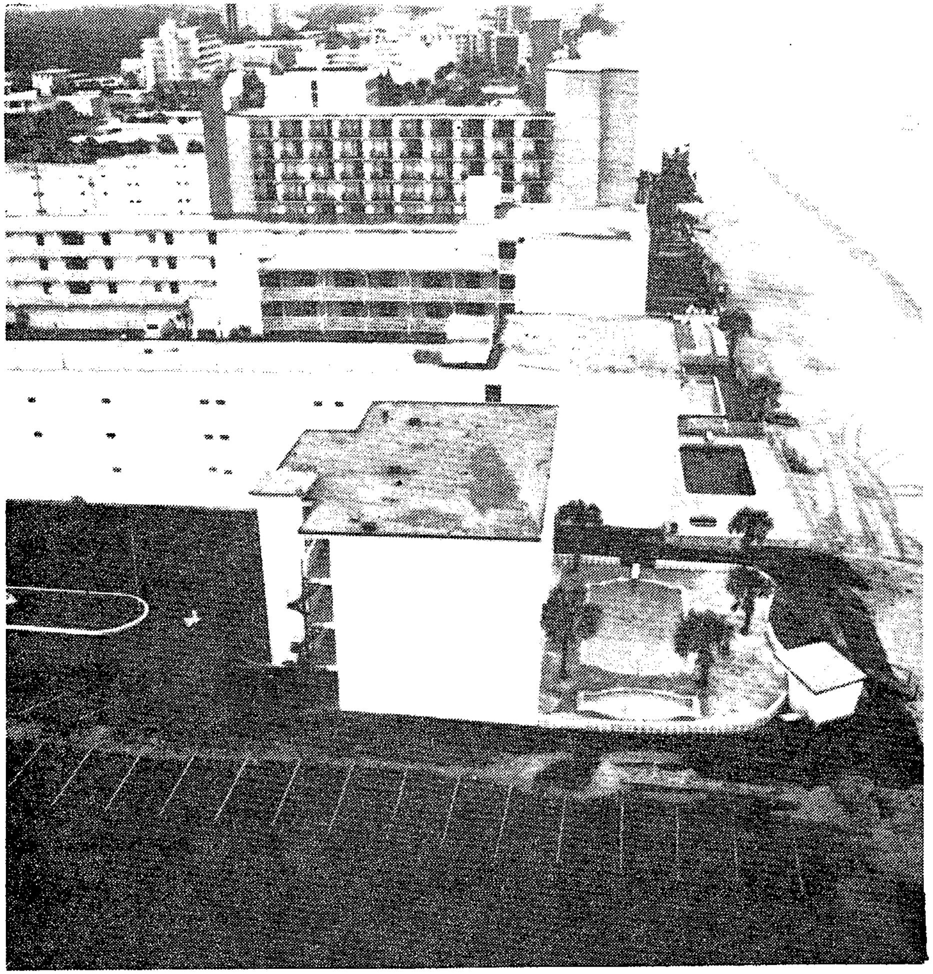
An understanding of the natural processes at work in the region is an important first step towards learning to manage storm drainage through improved land design.

A turn of the page is all you need to start



from rain to runoff to the sea

landscape and its natural processes



An understanding of the processes by which precipitation moves across and through the land to the sea helps reveal many answers to better storm water management.

The drawings on the next two pages show how area-wide drainage patterns occur in coastal Carolina.

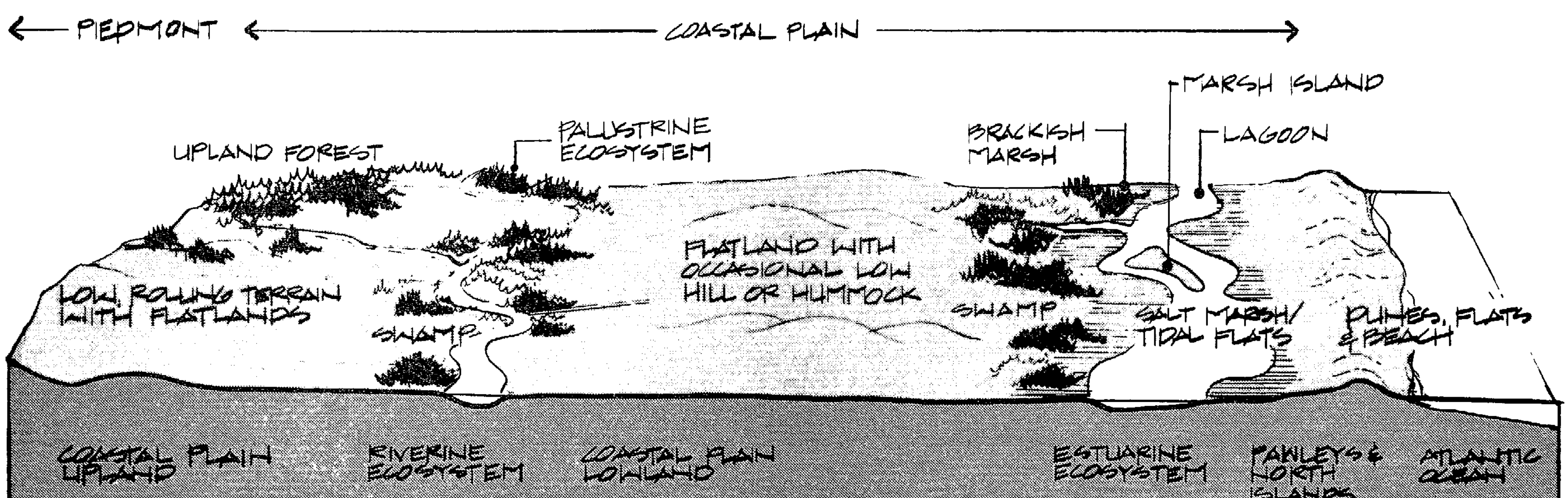
topography (landform)

Unlike the Piedmont region below which it lies, the coastal plain is characterized by low flatlands interrupted only occasionally by shallow rolling landforms never exceeding 75 feet above mean sea level. Along the coastline low dunes are found above the sand flats.

hydrology (water patterns)

Swamps and marshes edge the lower river reaches and estuarine waters of the region, while the water table found beneath even the better drained lands does not exceed four to five feet in most areas. Many areas are shallower than these. Near the coast, the influences of high tide and surging sea levels during storms act to worsen inland flooding as river and stream flows are impeded and the drainageways that feed into them are backed up. Even when sea levels are low, flooding and standing water are often experienced where the landform is too flat, soils are impermeable or heavy, a high water table prevails, and drainage systems have insufficient capacities.

Infiltration, or percolation, is the process by which precipitation moves downward through the upper soil layers. When water reaches the zone of water saturation (the "water table") or an impermeable layer of hardpan, it moves toward ditches, streams, or other drainageways which lie at lower elevations. When the entire upper soil layers become saturated, as during flood, or where paving or other impervious layers cover the land, rainfall will run off the surface as overland flow ("storm runoff"). During the initial moments of intense rainfalls, also, water carrying pollutants will shed over land surfaces without infiltrating, particularly where soils are bare of restraining vegetation, and transport pollutants to rivers, downstream wetlands, and to the beach surf.



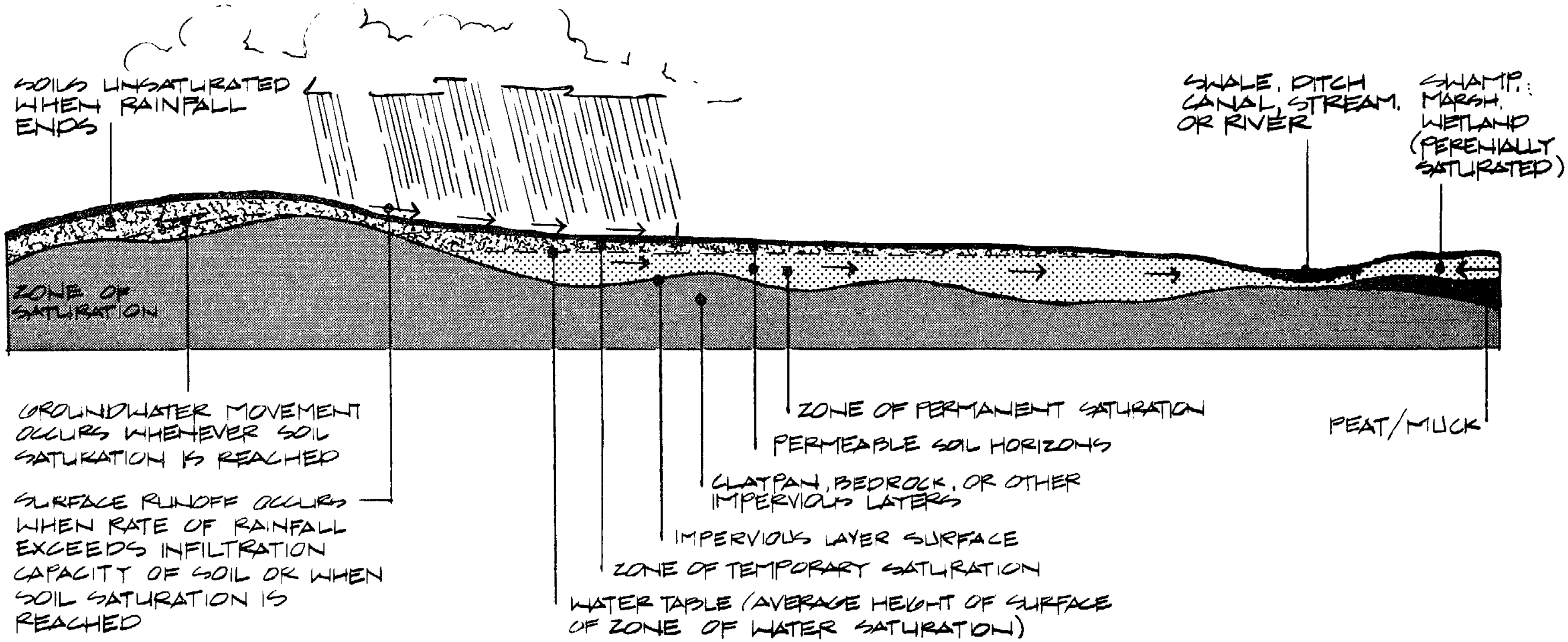
soils

Soils within the Waccamaw region are generally sandy in nature, varying from poorly drained to well-drained, depending on elevation and amounts of clay. One type of clay commonly found in the region is gumbo. Within the poorly drained lowlying marsh and riverine areas, eroded silts, clays, and fine organic matter are found carried by water flow from elsewhere within the region. Percolation is often poor where clay is abundant in soil. Standing water is common where a saturated layer of clay (claypan) exists beneath surface soils. Within the higher elevated and agricultural areas, sandy loams exist that contain concentrations of clay and fertile organic matter. Along the dune and beach areas coarser, highly permeable and well drained sands exist.

Well drained soils yield better building, roadway, and drainageway sites because of better percolation and drainage. However, where both poorly and well drained soils exist in proximity, it may be preferable to locate buildings, roadways, and drainageways over the poorly drained soils, if foundation conditions allow, and to allow for a larger infiltration area where the soils are better drained.

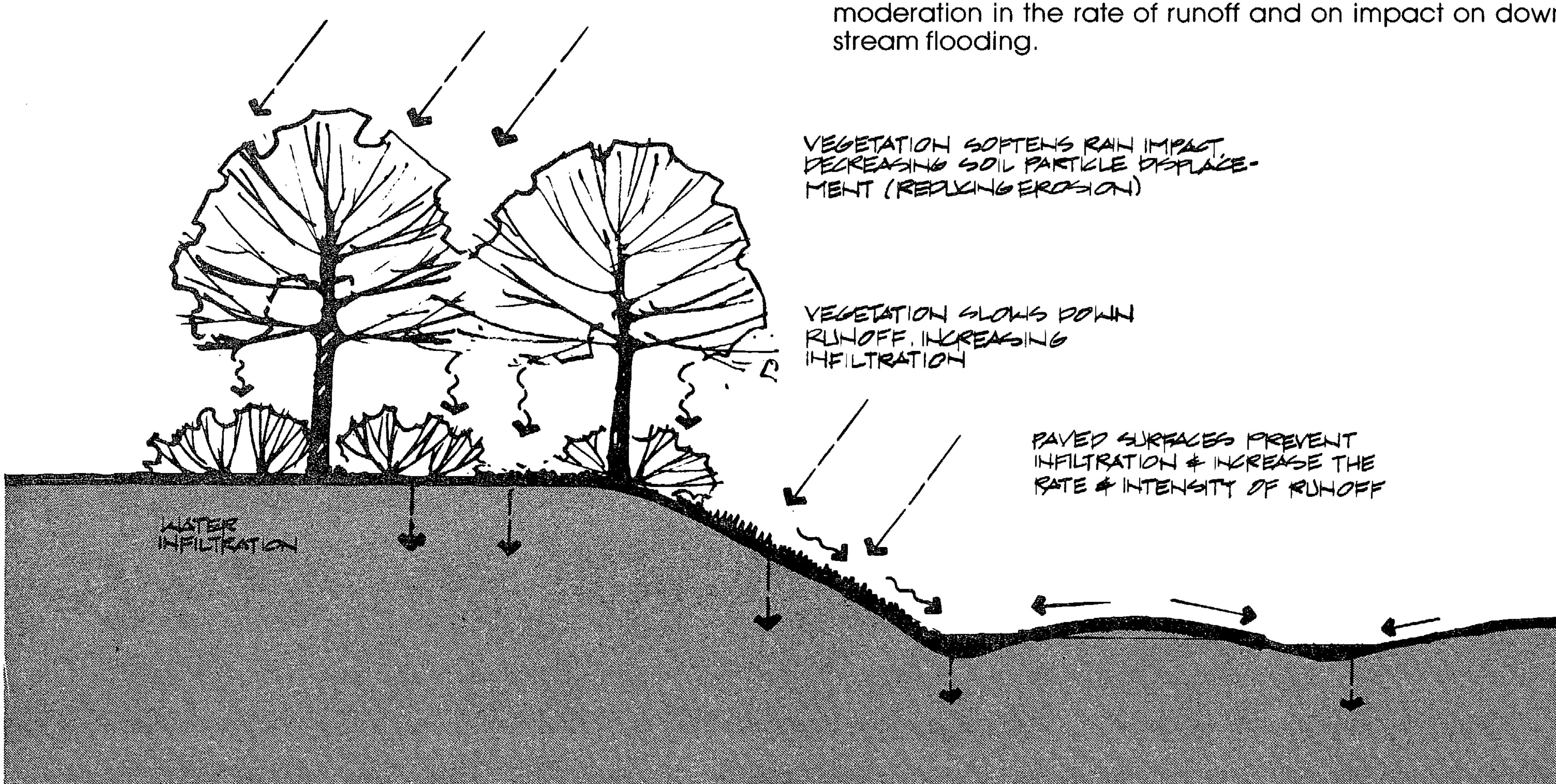
Appropriate measures should be taken when considering use of on-site sewage disposal units near less permeable soils or over a high water table.

Because drainage ditches and adjacent areas are susceptible to erosion, proper side slopes, spoil disposal, and drainageway gradients must be designed to minimize soil erosion, maximize infiltration, and decrease runoff and siltation.



vegetation

Vegetation impedes surface flow. Where soils can accept infiltration, vegetation can cut down the quantity and velocity of surface runoff and diminish erosion resulting from rain impact. Debris from vegetation can also clog ditches and reduce effective drainageway capacities, but fine-textured growth, such as mown lawn grasses and other ground-hugging covers, can preserve high drainageway capacities while moderately increasing friction in the ditch, swale, or ground surface, resulting in a degree of moderation in the rate of runoff and on impact on downstream flooding.



development and its effect on natural drainage

Changing land use within Horry, Williamsburg, and Georgetown counties over recent years has had an adverse effect on drainage within the region. Farm fields, areas developed for housing, shopping centers, commercial properties, and industrial areas have been developed in many instances without due regard to off-site drainage impacts, or even to drainage effects on the site itself.

Parking areas, paved roads, rooftops, and compaction of soil coupled with raised water tables resulting from septic tank drain field installation, clearing of vegetation from large areas, and elimination of drainageways during development all have created highly increased runoff. If these effects continue, existing drainage facilities will become increasingly overburdened and unable to handle runoff.

In order to improve drainage throughout the three-county region, the U.S. Soil Conservation Service (SCS) has proposed a regional drainage network consisting of main canals and lateral drainageways that would be dug along natural drainage paths to improve the flow of runoff in each watershed.

Improvement of local drainage techniques, however, guided by better land design, needs to be adopted by individual property owners and users, step by step with any improvements in area-wide or county drainage systems, if the latter systems are to work effectively.

Agricultural land drainage is one system that alters natural runoff for legitimate reasons, but increases the rate of runoff and volumes in public ditches and canals. Where poor farming practices are allowed, however, the runoff problem is compounded with field erosion — carrying away soil, pesticides, and fertilizers — which can pollute and silt in drainageways, estuarine marshes, and boating channels.

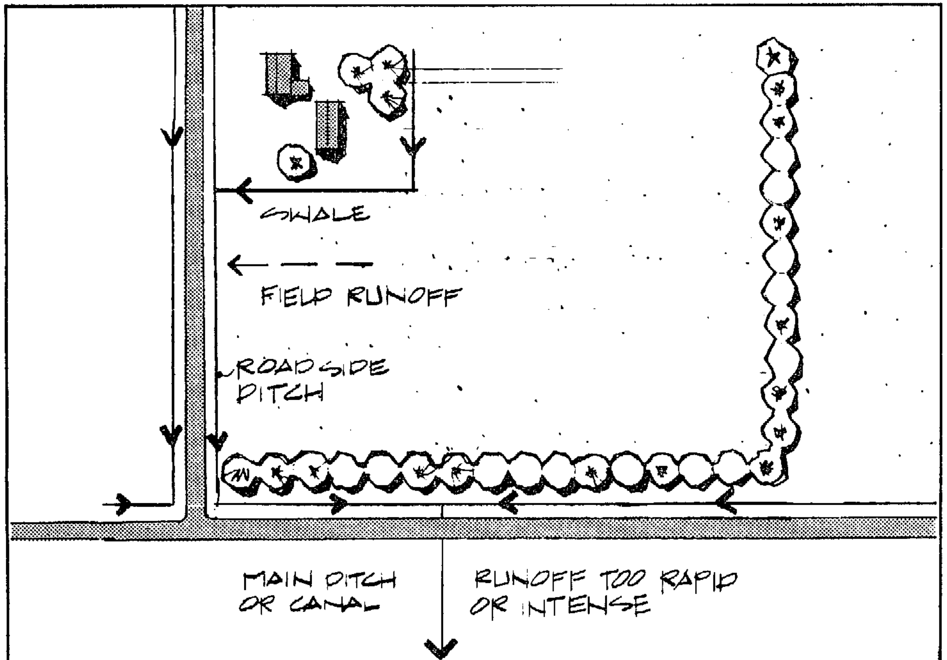
Residential development laid out in gridiron patterns with flat homesites and straightline ditching causes the rapid flow of runoff from rooftops, homesites, and impervious paved surfaces to surcharge downstream drainageways. Residential development imposed on the land without respect to natural drainage patterns causes flooding, erosion, sedimentation, and destruction to private, public, and ecologically important natural areas.

Commercial land uses, such as shopping centers and industrial properties, also contribute to a speeding up of the rates of runoff that would exist in the natural landscape. This is so because these areas are surfaced with impervious paving designed to carry water quickly and effectively away from customer access, parking, loading, and other areas, as well as the buildings, other structures, and valuable open lands on the property. In achieving this legitimate drainage objective, however, large volumes are carried rapidly into public ditches and streams.

Shoreline development is the major cause of dune destruction and beach erosion along the Grand Strand. Sand dunes and the natural areas directly inland that absorb and retain stormwater help protect inland areas from the brunt of major storms. These natural features, however, have been replaced by seawalls and other hard vertical surfaces that cause erosion and narrowing of the beach face. The rapid flow of runoff from impervious surfaces of pool decks, roadways, parking lots, rooftops, and other impervious surfaces, and drainpipes causes extensive erosion to the beach face, embankments, and pavement edges.

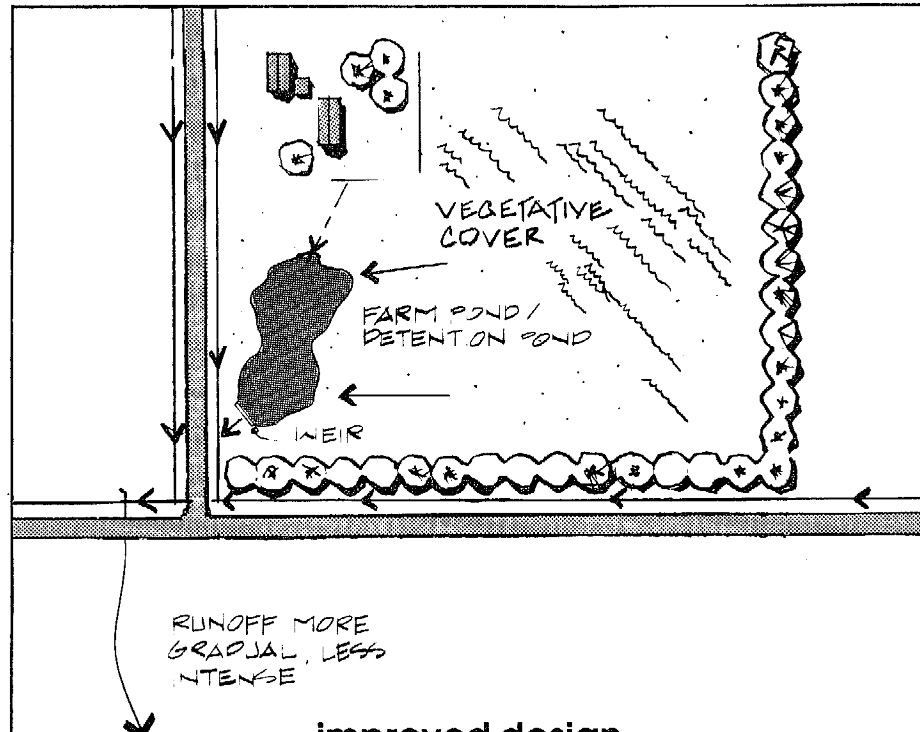
The following diagrams show how "not so good" and "good" local land design can affect area-wide drainage in agricultural, residential, and commercial situations.

a comparison of agricultural area roadside ditch systems



typical layout

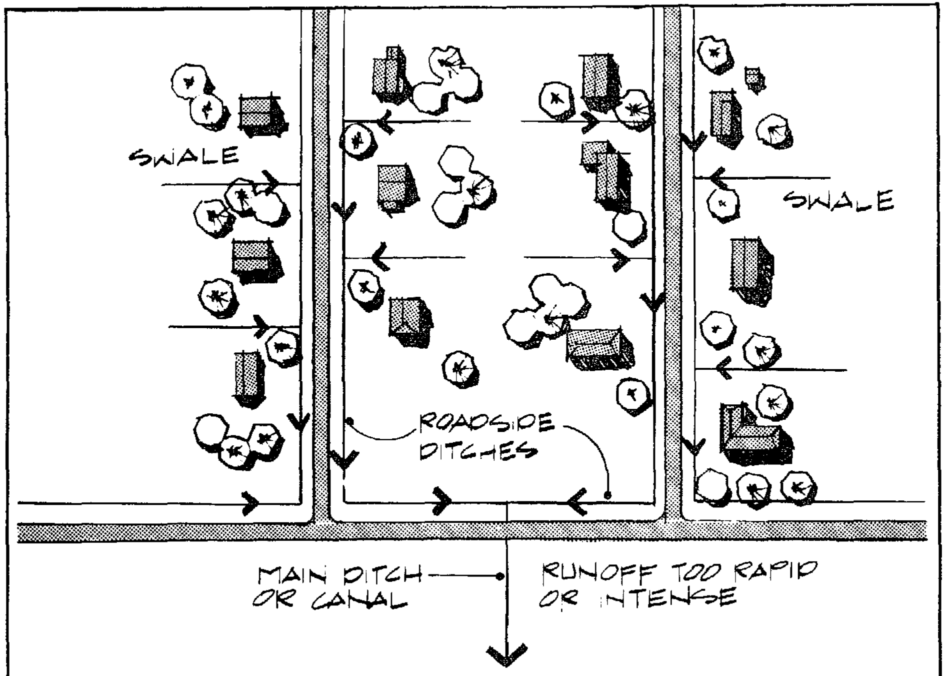
- Bare fields promote erosion of soil causing sedimentation of roadside ditches and downstream wetlands, waterways, and estuaries. Loss of pesticides and fertilizers is costly to the farmer and damaging to the environment.
- Poor equipment turns damage ditch edges and cause ditch blockages.



improved design

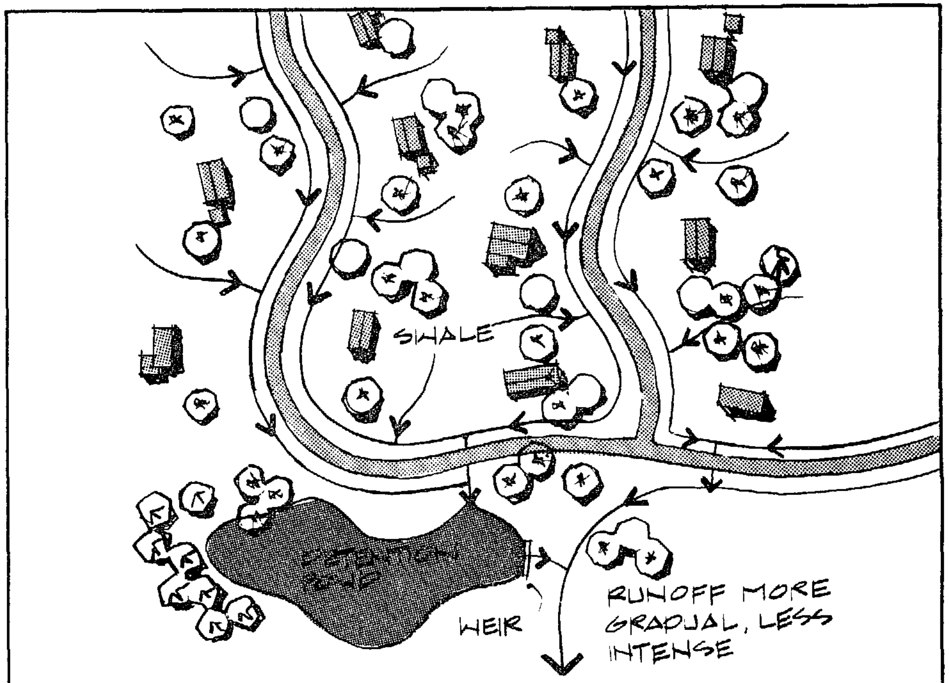
- Cover crops reduce runoff rate, erosion, and pollution of drainageways and downstream environment.
- Detention ponds slowly release water into main drainageways.
- Ditch edge buffer helps maintain ditch walls, alerts equipment operator.

a comparison of residential land design layouts



typical layout

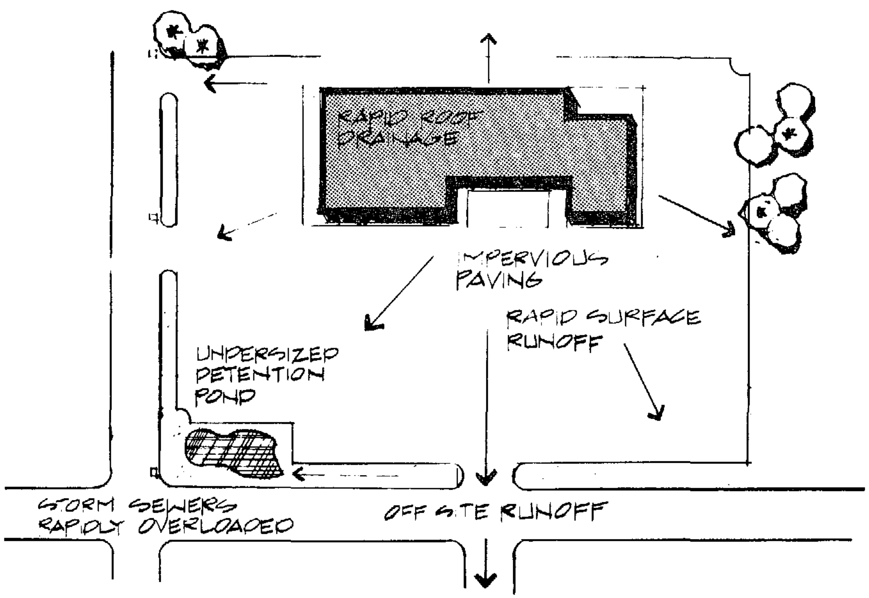
- Ungraded flat land leaves homes and other buildings close to elevations of surface flow.
- Straight-line swales and ditches carry water away from homes and farms but are limited in infiltration capacity.
- Head drainageways often short-cut across topography, resulting in too rapid a runoff rate, further surcharging downstream drainageways and causing them to overflow.
- Cleared vegetation does not allow for rainfall interception, increases runoff rate, and does not allow for absorption of rainfall.



improved design

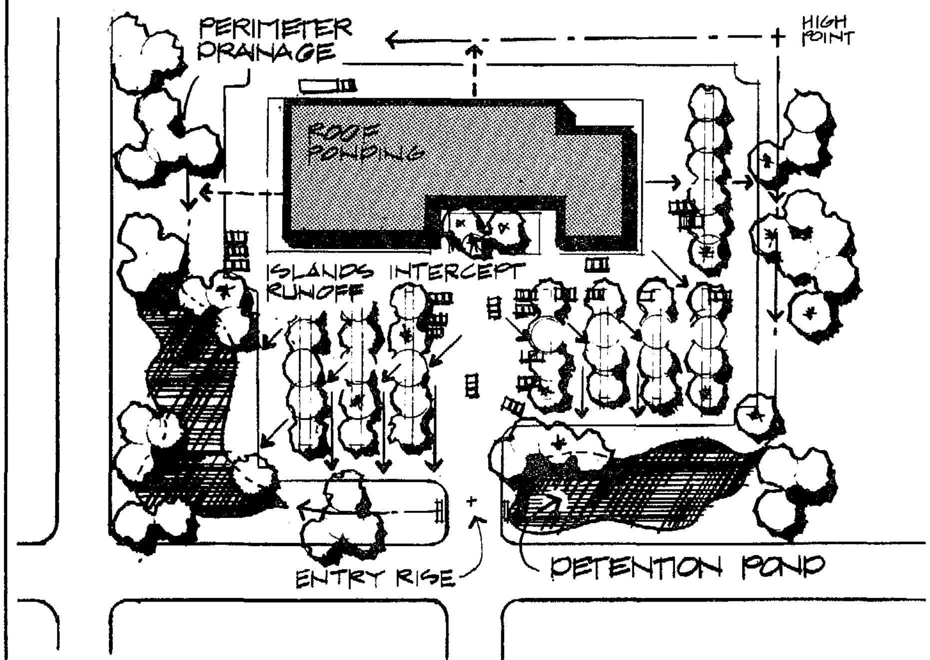
- Land graded into mounds and swales allows buildings to perch higher above the water table. Curving swales take more water and release it more gradually to downstream drainageways.
- Detention ponds release water more gradually over weirs, set at calculated heights.
- Vegetation softens rain impact, decreases overland flow, and allows for absorption.

a comparison of commercial land design layouts



typical layout

- Impervious rooftops and paved surfaces shed runoff off-site with high intensity.
- Escaping runoff overloads municipal storm drains or flows across street surfaces to damage other property or beaches.

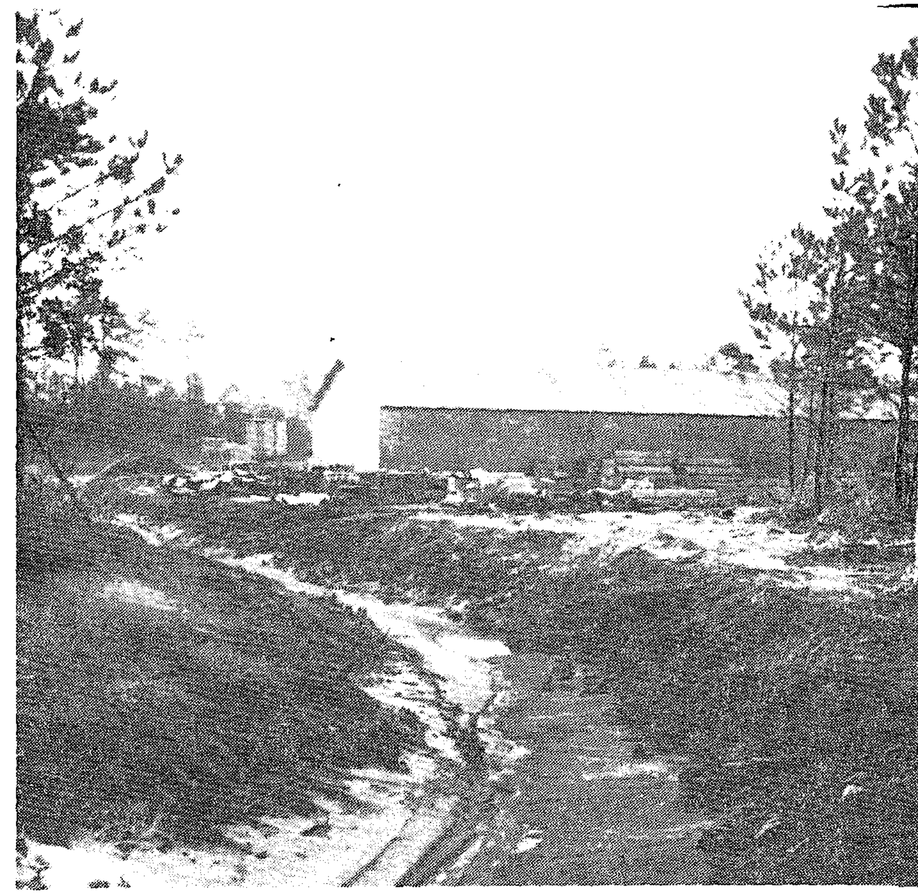


improved design

- Roof ponding, porous paving, and uncurbed median strips help to reduce the rate and amount of runoff.
- Perimeter drainage retains runoff on-site while detention ponds slowly release water to an off-site outlet.

problems & solutions

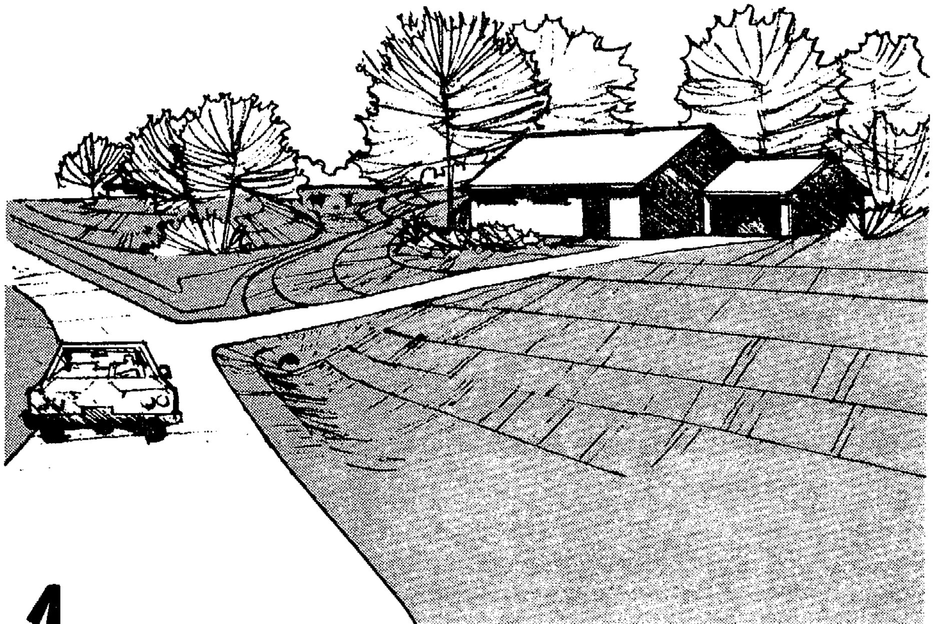
principles for improved drainage



As we have seen, there are right and wrong ways of controlling drainage. The techniques proposed in this handbook are based on simple principles that are by no means new. They have been and are being used in coastal Carolina, though not as widely as they ought to be.

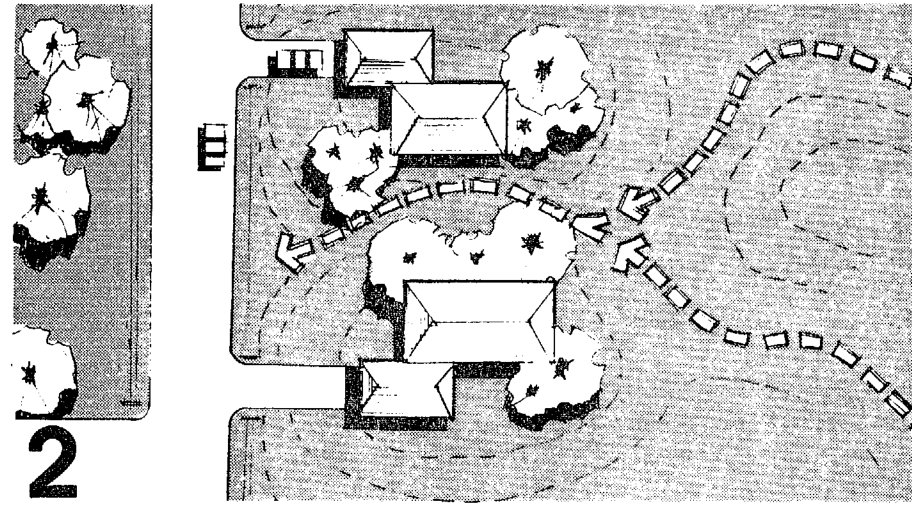
To properly control drainage the following principles should be applied to land design.

problems and solutions



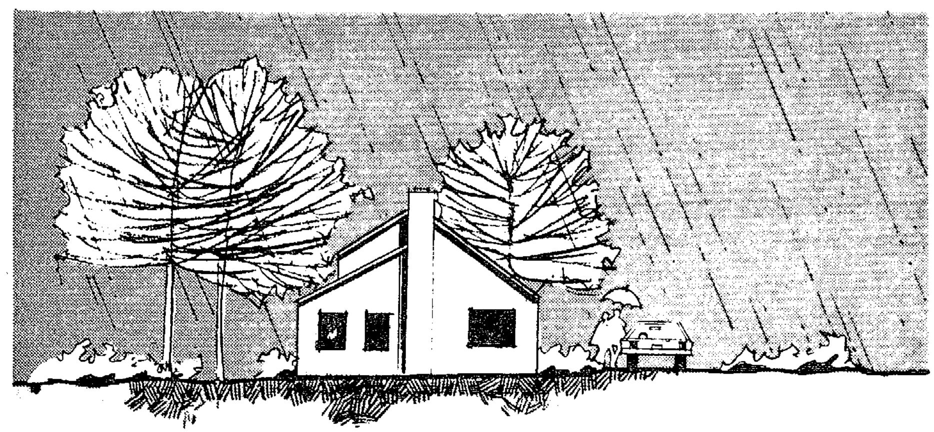
1

design and modify landform to create high and low points in advance of building construction to create higher elevations for houses and other valuable property areas, and lower elevations for broad swales, ponds and other drainageways.



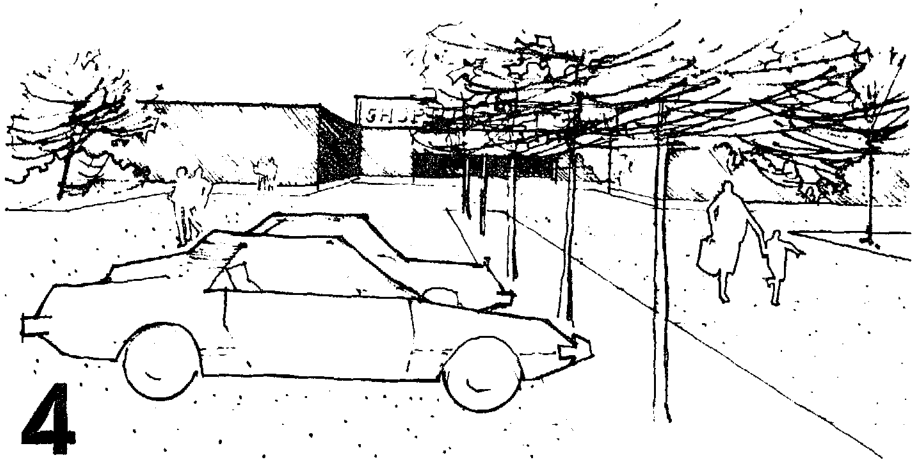
2

provide curves in swales and other on-site drainageways so that runoff will travel longer and at a lower gradient before reaching outlet points, following landforms wherever possible.



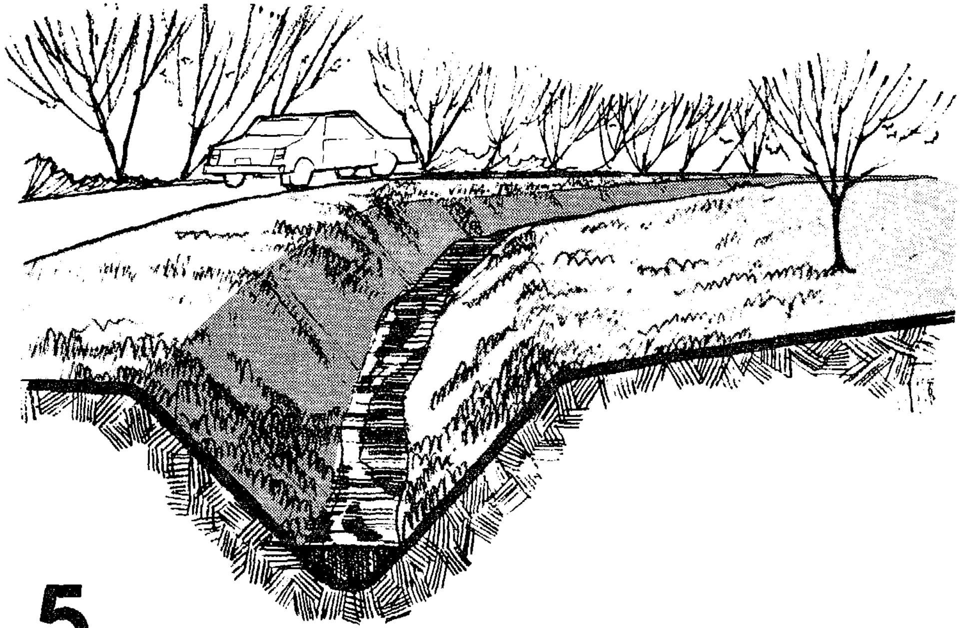
3

maintain absorptive surfaces while planning development wisely by leaving as much of the absorbent surfaces as lawn, garden, or natural areas.



4

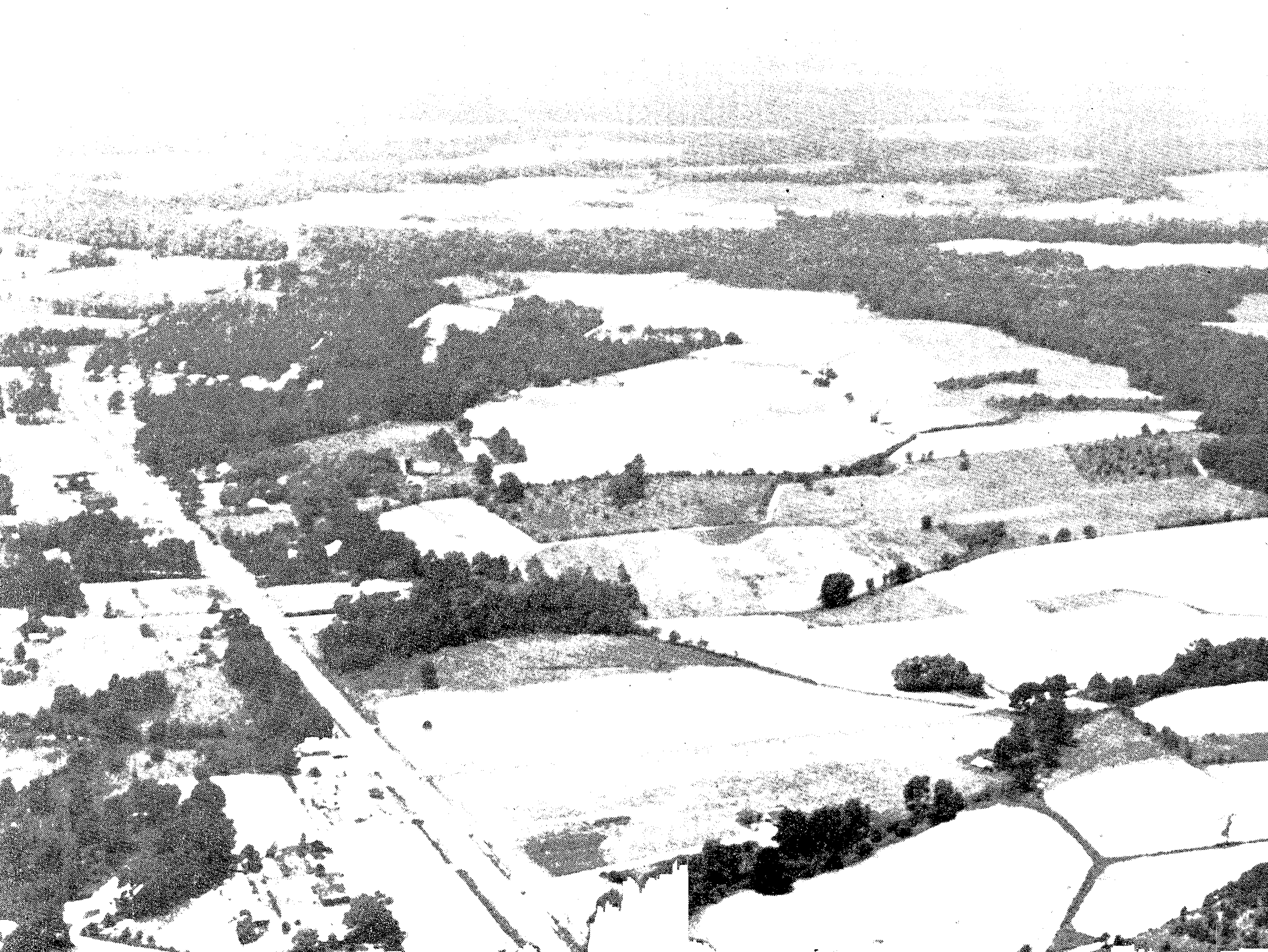
use porous paving instead of impervious paving particularly where parking areas are extensive, in conjunction with well-graded planted median strips.



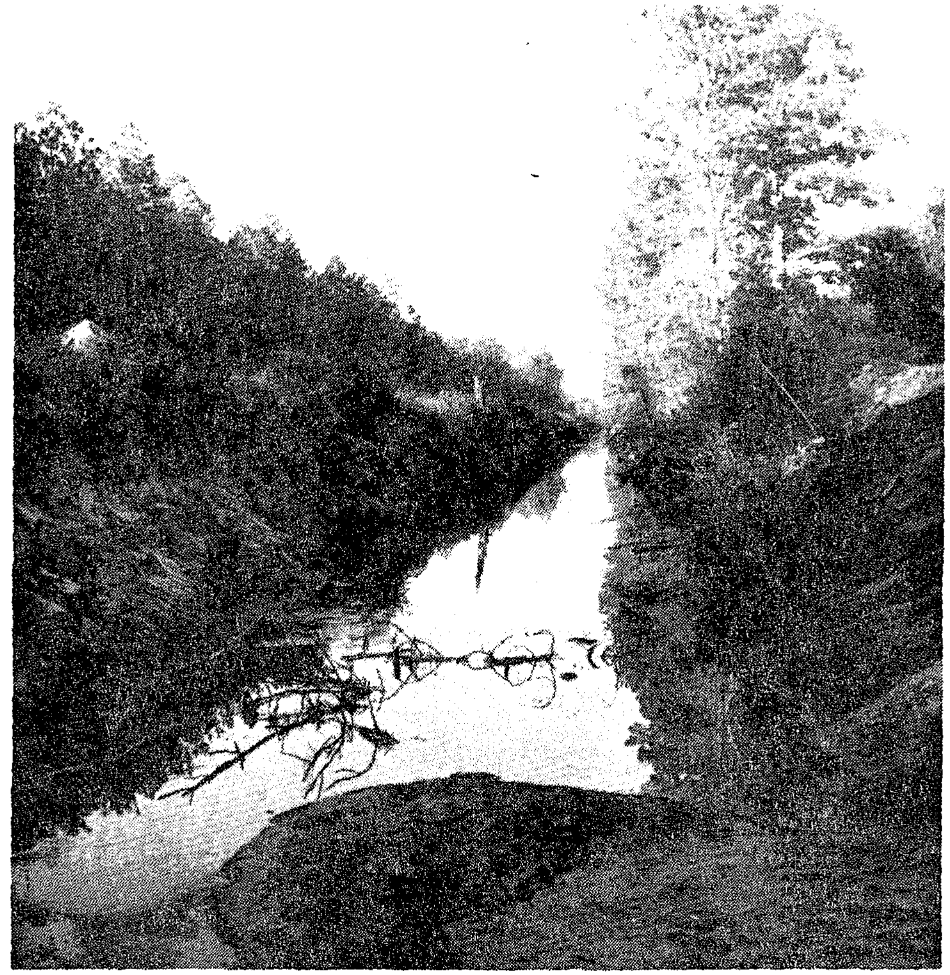
5

design and maintain ditches to last with a minimum of ditch wall erosion and sedimentation.

If these simple principles are followed by homeowners, site planners, designers and others, it is very likely that an improvement in local drainage can be achieved. The techniques presented on the following pages are the specific action steps that can be taken to reach this objective.

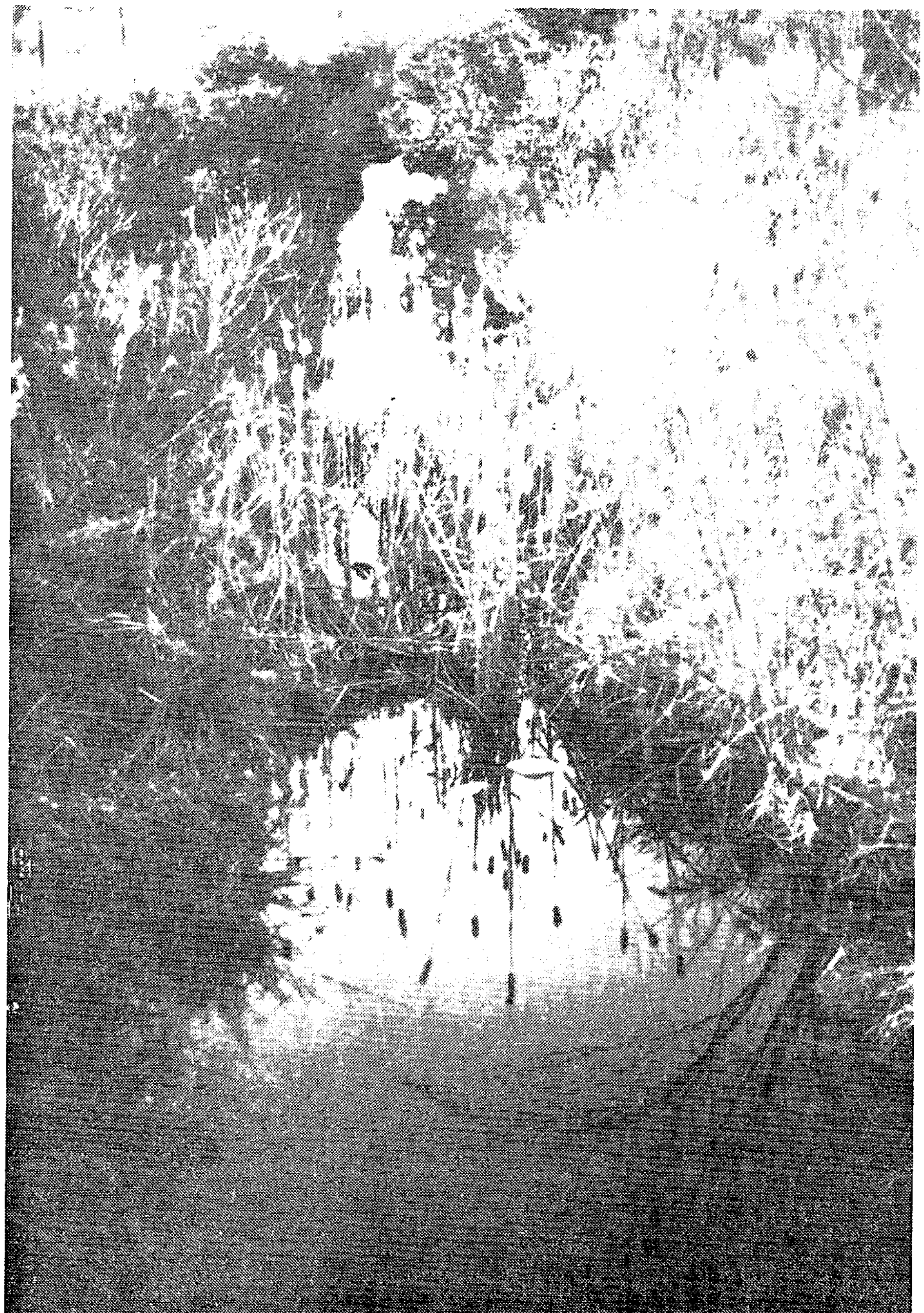


agricultural lands



Poor farm practices, lack of adequate ditch design, and improper ditch maintenance have caused erosion, sedimentation, and flooding to occur on farm fields, adjacent drainageways, and downstream points. To reduce these adverse effects and the impact of pollution on downstream wetlands and estuaries, improved management measures need to be adopted.

These can be found on the following pages.



the problems

In agricultural areas, roadside ditches are sometimes silted in as the result of **steep wall ditch design,** which allows crumbling of erodible soils. Two other typical problems are the **mounding of ditch and canal excavation spoil too close to the drainageways,** a negligent practice which allows rainfall to wash the spoil right back into the channel, and **farm equipment turns too close to roadside ditch edges,** which can result in direct assault on the ditch crest.

Another contribution to the sedimentation of ditches has been the practice of some of **leaving farm fields bare of cover between cash crops.** Unprotected fields are easily eroded by strong rainfalls since there is **no foliage to absorb impact and decrease the flow rate** of stormwater runoff. Without the restraining action of crops or other cover vegetation, **great amounts of topsoil, fertilizer, and pesticides can be carried away and seriously impact stream, wetland, and coastal environments.**

When ditches and drainageways fill in because of these poor practices, the **potential for back-up and flooding** of crops increases, often resulting in **significant dollar losses.** Filled in ditches also mean higher county, municipal, and private **maintenance costs.**

the solutions

Many improvements to faulty drainage ditch design can be found. Many problems of poor design and maintenance can be overcome if the following procedures are followed.

ditch design

Drainageways should ensure efficient roadside flow by proper vertical placement of ditches, culverts, and pipe inverts. Elevations should be set by a qualified professional to avoid local blockages and overflow.

Proper ditch design will make sure that agricultural land is well drained.

- **Side slopes** of sandy unstable soil should be cut at 45%. In areas where clayey soil exists, 60% is acceptable.
- **Equipment** should be carefully selected — a V-bucket for ditches three feet or less in width and a dragline for larger ditches.
- **Grasses,** such as tight-growing Bahia, Bermuda, and Common Lespedeza should be planted on ditch bottoms, slopes, and adjacent areas to stabilize soil and restrict weed growth.

spoil disposal

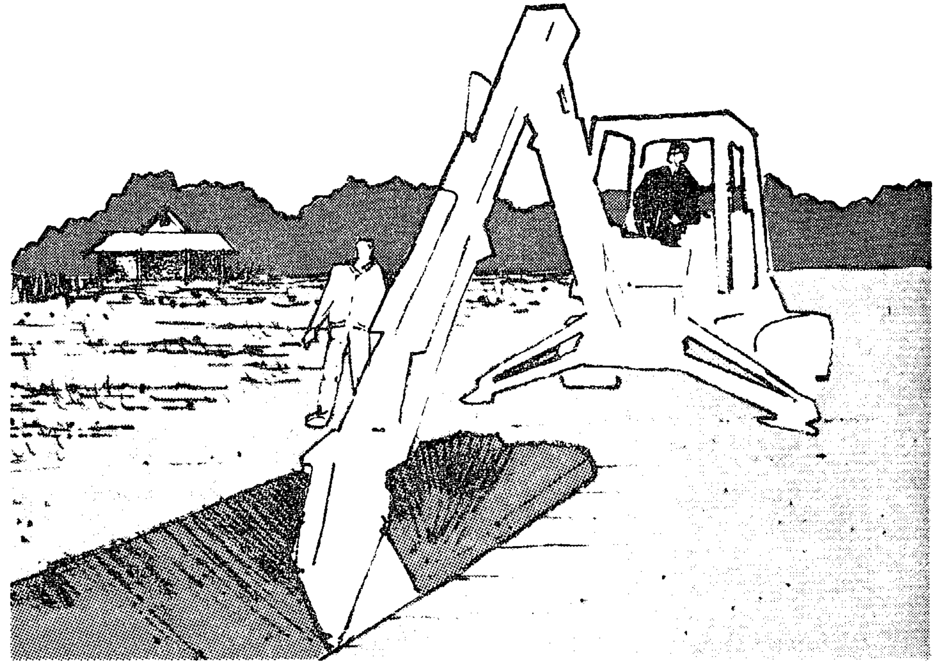
Material excavated from drainageways should be handled properly. If it cannot be spread over the land, it should be piled as far from the ditch as possible.

- The **location** of spoil should be set back from ditch edges to prevent it from washing back into the ditch and reduce excess weight on the ditch wall.
- **Open spacing** should be provided between piles for drainage.
- **Mounds** should be seeded with suitable grasses after excavation to provide spoil stabilization.

improved field practices

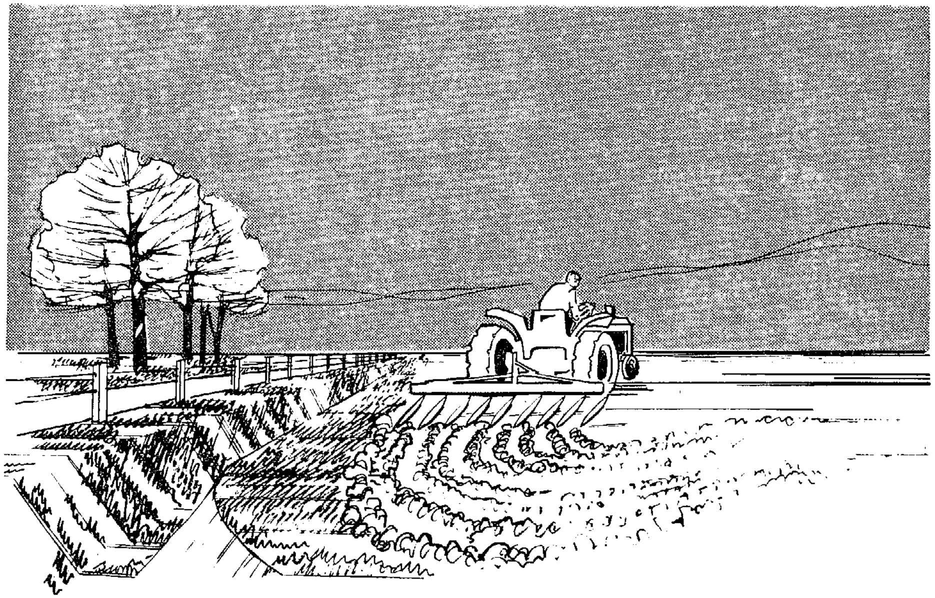
Ditch sedimentation can be reduced by eliminating soil erosion resulting from poor field practices.

- **Crops** such as barley, oats, rye, or winter wheat should be planted during periods when fields are otherwise left without vegetative cover.
- A **planted buffer** between the ditch edge and turning border should be left undisturbed to prevent equipment damage to the ditch.

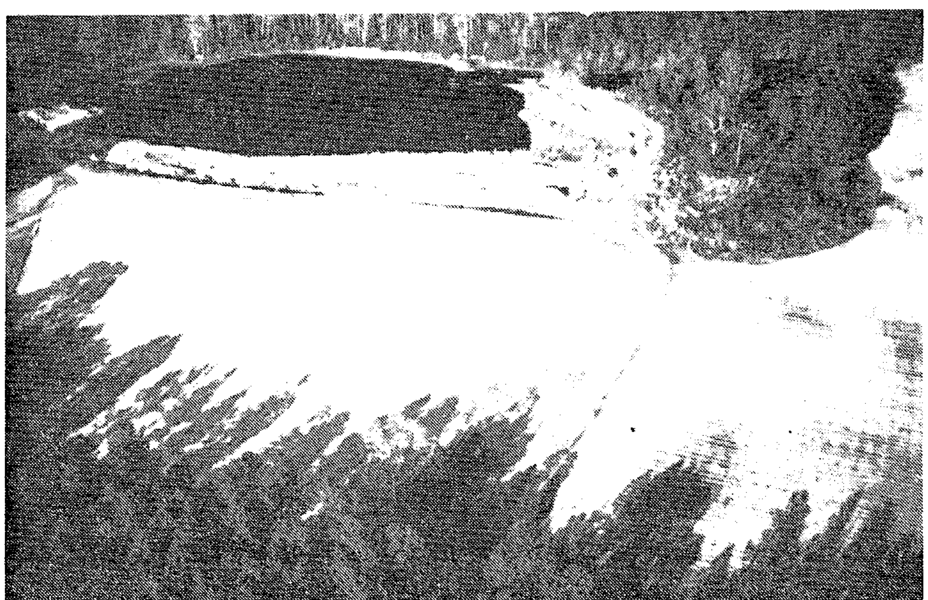


drainage ditch design

spoil mound placement and seeding



Adequate setback of turnarounds from ditch edges is essential. A buffer of thick grasses can reduce erosion.



farm pond, Williamsburg County

- **Detention ponds** should be excavated at suitable low points to detain and retard stormwater runoff and for livestock watering.
- **Weirs** at pond outlets should be sized and located to ensure that outflow to downstream drainageways is managed at the lowest discharge rate possible without causing flooding from the pond.

maintenance

In order to maintain their runoff carrying capacity and reduce flooding, routine maintenance should be performed on all ditches.

- **Plant debris** and other matter that can obstruct water flow should be cleaned from ditches and disposed of so that they will not re-enter the drainageway.
- The **stability** of ditch walls and spoil mounds should be checked.
- **Exposed spoil** should be seeded with recommended grasses.

residential areas

Poor site conditions on flat lands and poorly designed stormwater control methods in residential areas have led to flooding of on-site housing as well as lands in downstream areas. Early in the site planning process, problems of excessively flat topography and stormwater control need to be addressed and appropriate land design measures selected to improve drainage, reduce flooding, and enhance land values.

Solutions for achieving these goals through improved land design can be found on the following pages.

the problems

poor site design

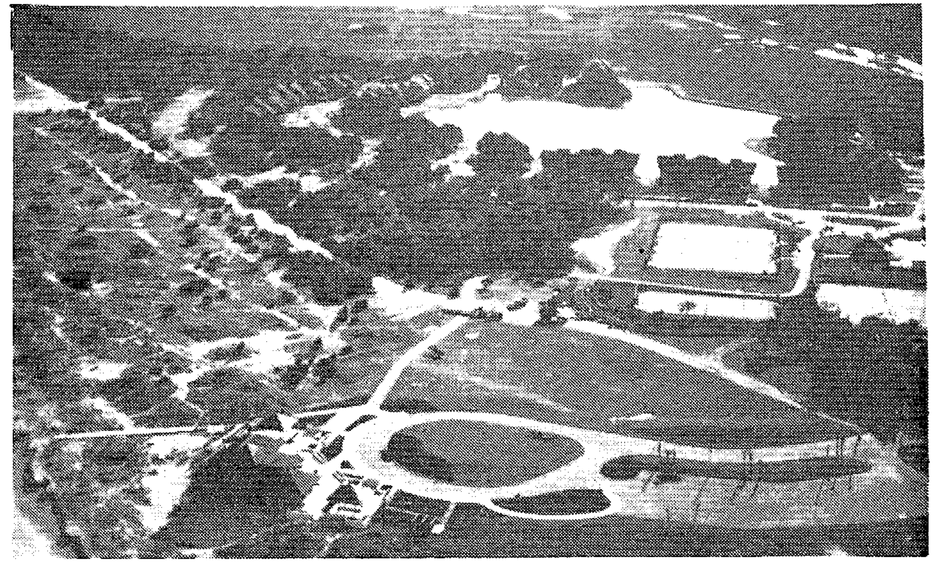
Residential areas and subdivisions have often been laid out in gridiron patterns with **flat homesites** and **straightline ditching.** Even though straightline ditching allows for rapid on-site drainage, such design may allow runoff to accumulate and **surcharge downstream drainageways,** with little help to the homes they serve. Instead, flooding to properties, roadways, and natural areas results in times of heavy or moderately heavy rainfall.

For disposal of stormwater, landowners and developers have relied on poorly designed drainageways, inherited from the past, that connect and discharge into the larger county system. Often, these inadequately designed local and county drainageways which lack proper outlets flood because of sedimentation from rapid runoff caused by new residential development. Eroded sediments accumulate in wetlands and estuaries, upsetting nutrient flows and smothering habitats valuable to fish, shellfish, and wildlife.

Then, too, **surface shedding** from parking lots, driveways, walkways, rooftops, and other impervious surfaces **accelerates the arrival of runoff at outlet points and increases flooding potential downstream.** On flat land, in the absence of a raised homesite, there is little recourse for the homeowner during a heavy rain except to hope for clearing skies.

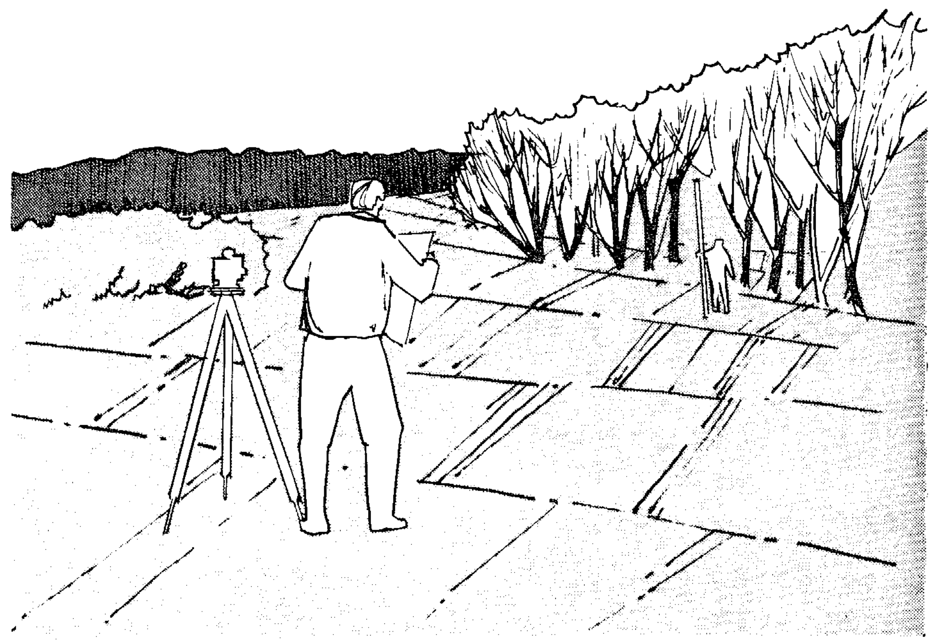
the solutions

Runoff in residential areas developed on basically flat land can be better managed if the land can be graded into landforms of a more rolling character. On the one hand, the curving, meandering swales that carry runoff will allow somewhat more time, as well as space, for runoff to move across and off the site than is allowed in straight-line ditching, providing greater opportunity for water infiltration into the soil (through the swale shoulders) and a less intense outflow into the main ditch system. On the other hand, the higher ground formed with the soil excavated from the swales supports homes at higher elevations and protects them from wet foundations and flooding to a better degree than existed on the original lay of the land.



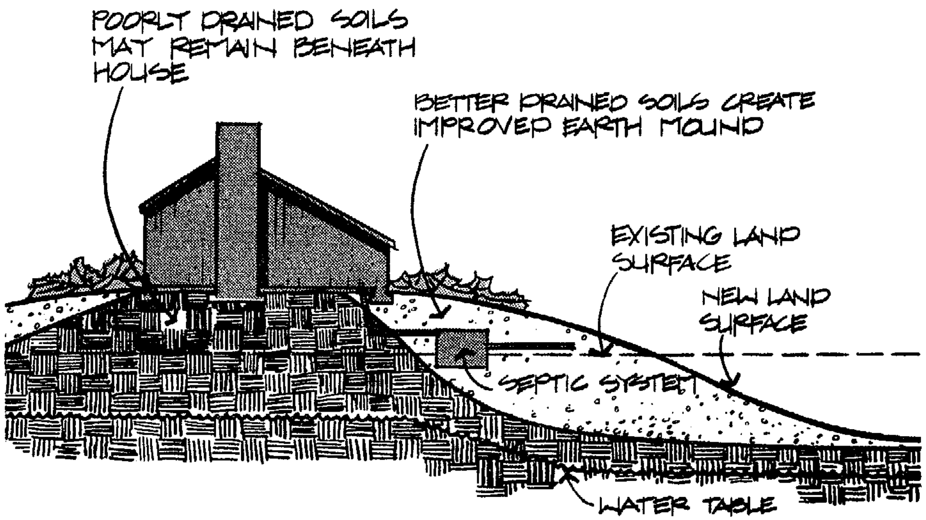
Because all soil types and depth to groundwater play such an important role in controlling drainage, it is essential that information about the topography and groundwater of the land be obtained before a site plan is drawn. The Soil Conservation Service or County Agricultural Extension can provide general information on soil characteristics such as absorption and percolation capabilities as well as depth to water table.

South Carolina Department of Health and Environmental regulations require avoidance of septic system development on unsuitable soil types and over shallow water tables. These criteria and minimum drainage requirements of local subdivision regulations, where they exist, should be met in any housing development. For specific investigations of site absorption, percolation, and water table depth, a competent consultant should be retained.



Map drainage patterns, determine soil suitabilities, and establish water table depth.

Finally, mounding to provide raised elevations for homesites, if accomplished through sensitive landscape design, can produce a quality image, improved property values, and a more liveable environment.

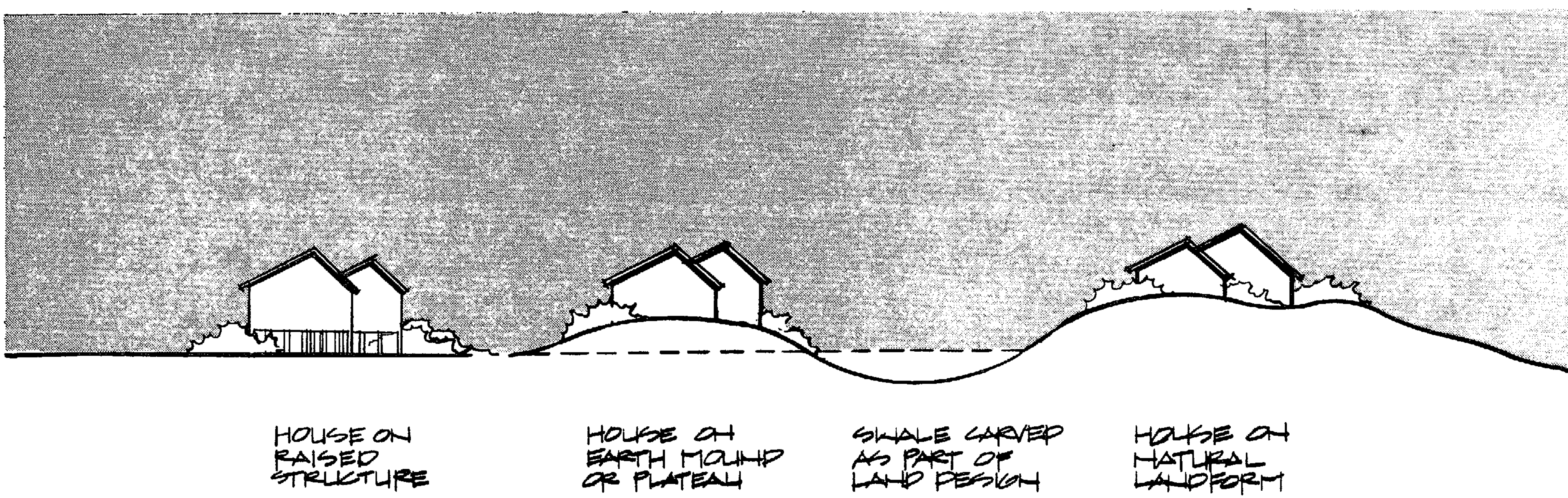


Both flood protection and groundwater protection are improved.

mounding

Where individual lots are large enough, mounding can be accomplished by building on earth fill. Mounds of sandy soil help water drain into swales and away from structures and ensure a safe height above the water table for living areas and septic systems.

- **Slopes** should allow for ease of mowing and permit a uniform, non-erosive rate of runoff flowing into adjacent swales.
- **Landscaping** of mounds will assist in runoff control while improving the aesthetic appearance of homesites and residential areas.
- **On-site sewage disposal units** should be placed in porous soil away from less permeable soil, and away from shallow water tables.



Raised structures may appear unnatural on flat terrain, while buildings on raised earthforms can appear compatible with natural terrain.

swales

Runoff from raised homesites and areas where impermeable soils predominate should be slowed in its progress toward the main drainageways by flowing toward and through gently sloped, grassed swales.

- The **location** of swales should be along natural drainage paths in the lower and border areas of sites.
- The **grading** of swales should be designed to assure the flow of runoff into roadside drainageways so that standing water does not occur.
- **Side Slopes** should be designed to allow for a slow, even flow of runoff, enabling the swales to absorb water and reduce downstream flooding.
- **Grasses,** such as tight growing Bahia and Bermuda, among others, should be planted in swales to help slow runoff, stabilize soil, and slow weed growth.

roadside drainageways

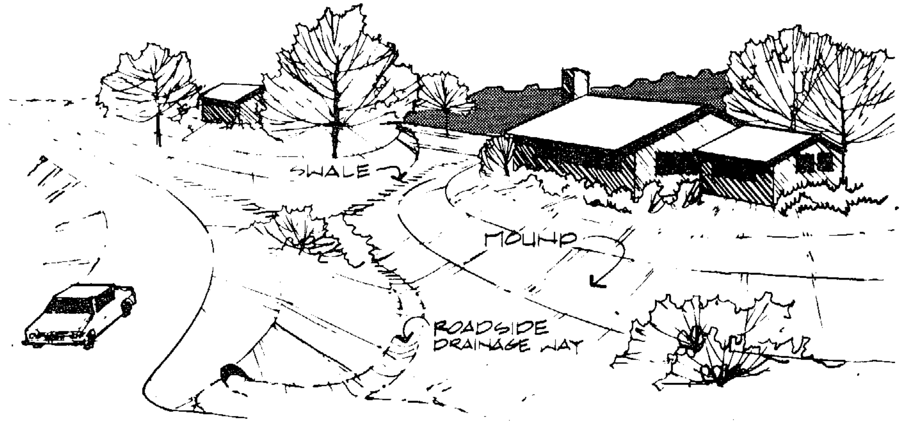
Roadside drainageways collect water from swales, homesites, and roadways.

Steps should be taken to ensure efficient roadside flow by properly locating ditches, culverts, and pipe inverts. Elevations should be specified by a qualified professional to avoid local blockages and overflow.

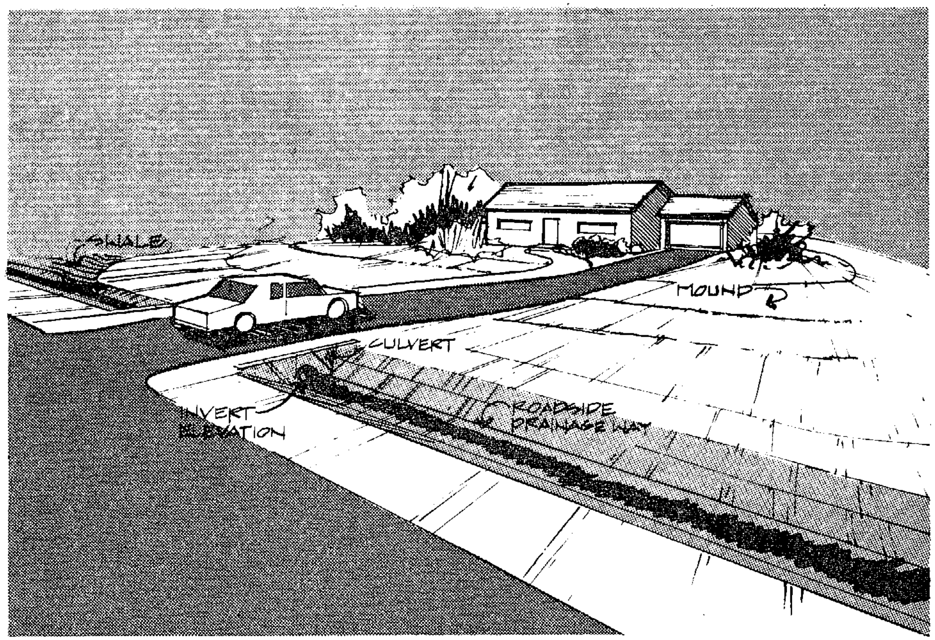
- The **design** of residential roadside drainageways should follow the guidelines described previously in the agricultural roadside ditch design section.

natural vegetation and landscaping

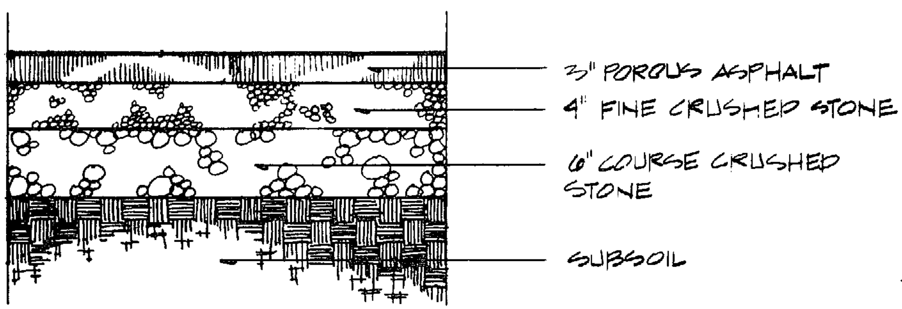
Vegetation improves the visual quality of homesites and enhances property values. A local landscape architect can best provide information on plant types, their availability, design, and other pertinent landscaping information.



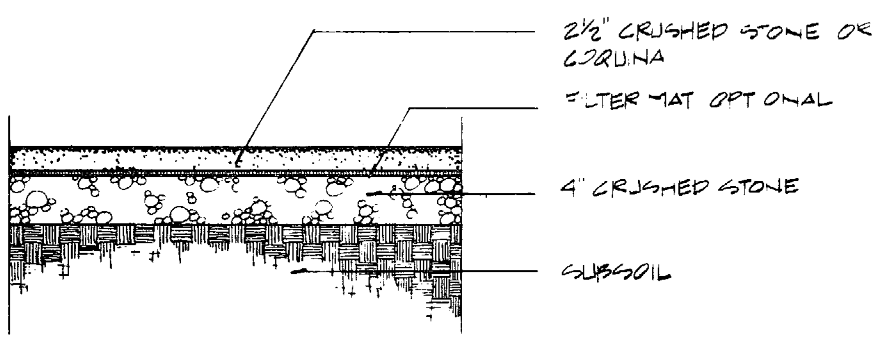
Where homesite lots are large enough to be modified from flatland to a varied topography, a valuable flexibility becomes available to the homeowner or developer. For the home can now be set higher and drier, while swales in new low points collect and lead water safely away.



Proper widths, slopes, and elevations of roadside drainageways are essential as are adequate culverts.



popcorn paving/porous asphalt



aggregate paving surface

- **Natural vegetation** should be retained and **trees and shrubs** planted on homesites. Low, dense grasses should be maintained on lawns to soften initial rain impact on soil and slow runoff.

permeable paving

In sites where sandy absorptive soils exist, the use of permeable type pavings should be considered, since they allow infiltration of runoff into the soil and slow down the rapid flow of water to swales and ditches from hard surfaces. Water moves through permeable paving into a layer of gravel and then filters naturally into the underlying soil. The Waccamaw Regional Planning and Development Council can provide advice on local sources, costs of permeable paving, and conditions of use.

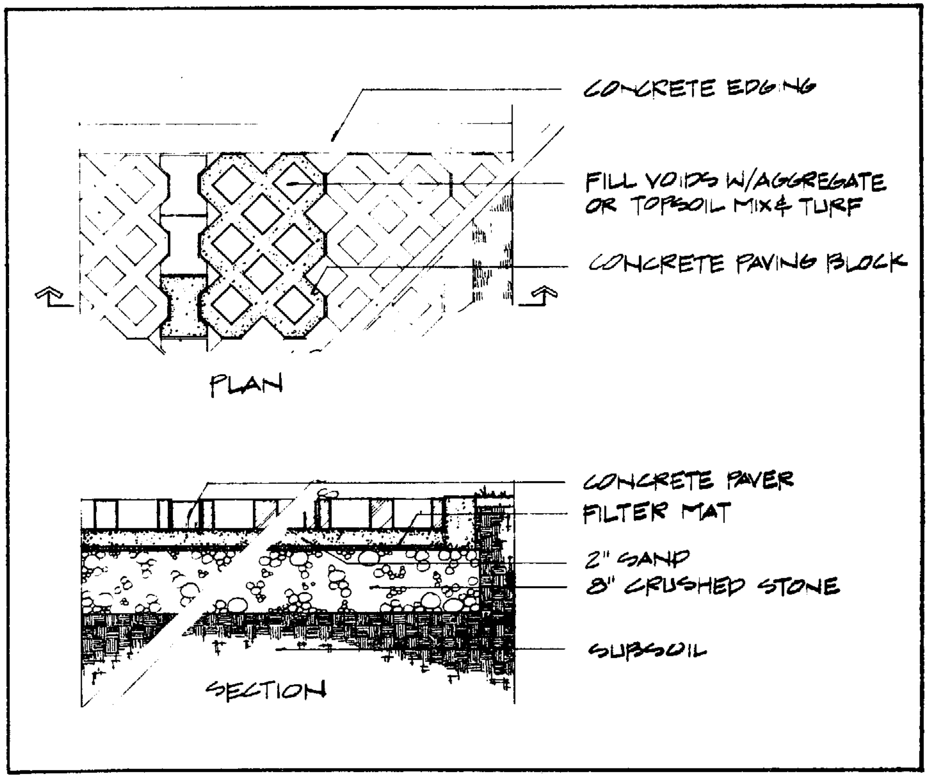
- **Porous asphalt paving,** commonly known as popcorn paving, should be used on driveways, parking areas, and road surfaces because of its ability to absorb runoff and reduce surface flow. Its strength and stability make it acceptable for a great range of access and parking conditions.
- **Lattice block pavers** contain hollow voids and may be filled with sand, crushed stone, grass over porous soil, and other porous material. Their use can be best applied to special parking areas where low speeds are suited to their masonry quality.
- **Precast interlocking and brick pavers,** set on sand for increased absorption, can provide a hard support surface for pedestrian use on patios and sidewalks and for vehicular parking. Precast pavers are somewhat more expensive than concrete, although they are more effective in reducing runoff and are visually pleasing.

- **Aggregate paving, such as gravel, crushed stone, sand, or cinders** can also be used in areas of pedestrian and low-speed vehicular use. They provide better infiltration than the popcorn paving and pavers set in sand, although they do not possess their stability and require greater maintenance.

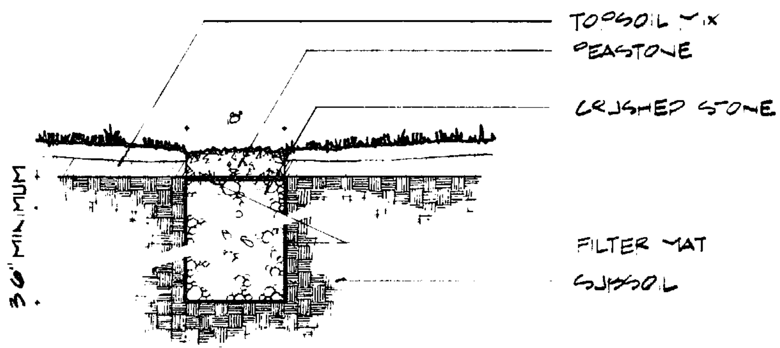
infiltration structures

Infiltration pits, dry wells, Dutch drains, and French drains can receive runoff from roof eaves or downspouts, driveways, or large lawn areas, and allow it to be absorbed directly into the lower layers of the soil. Since soil will accept less infiltration with continuing rainfall, pits, dry wells, and other stone-filled drains are most effective at the beginning of storms.

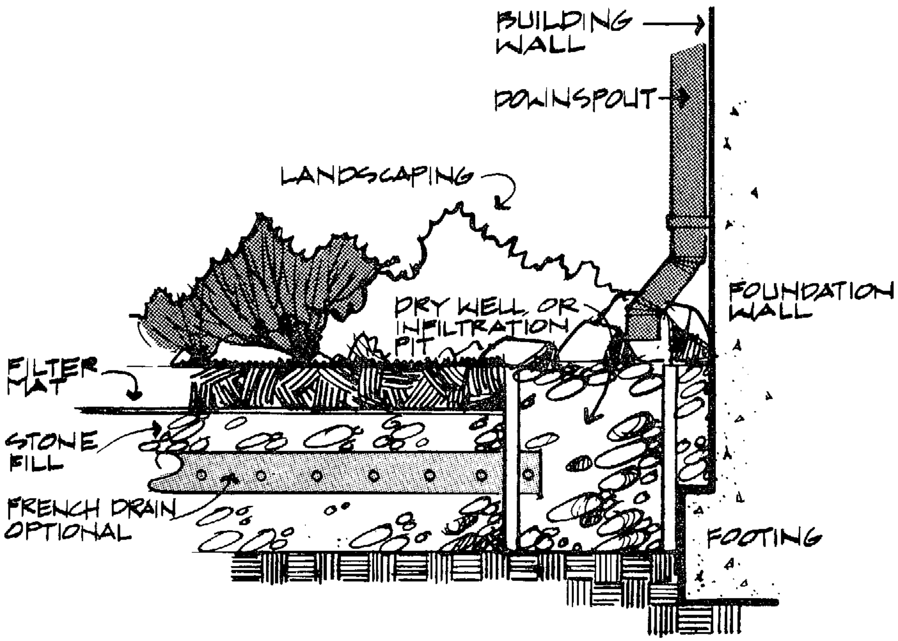
- **Infiltration pits** dug directly into the ground and filled with gravel or porous rubble that is separated from the soil by a filter mat can be used to intercept and absorb runoff. The filter mat will prevent soil from clogging the porous gravel and decreasing infiltration. These pits can also be used to lower the water table in desired areas. Linear infiltration pits or trenches are commonly referred to as Dutch drains.



lattice block paving



infiltration pit/trench



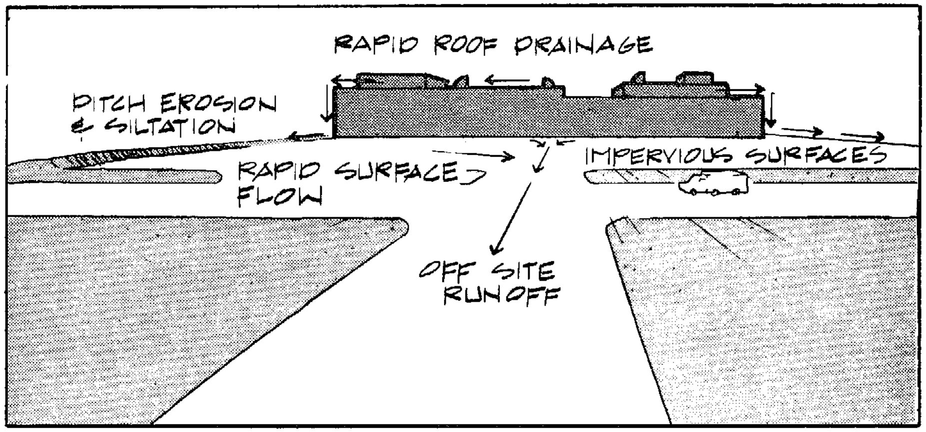
roof downspout drainage system

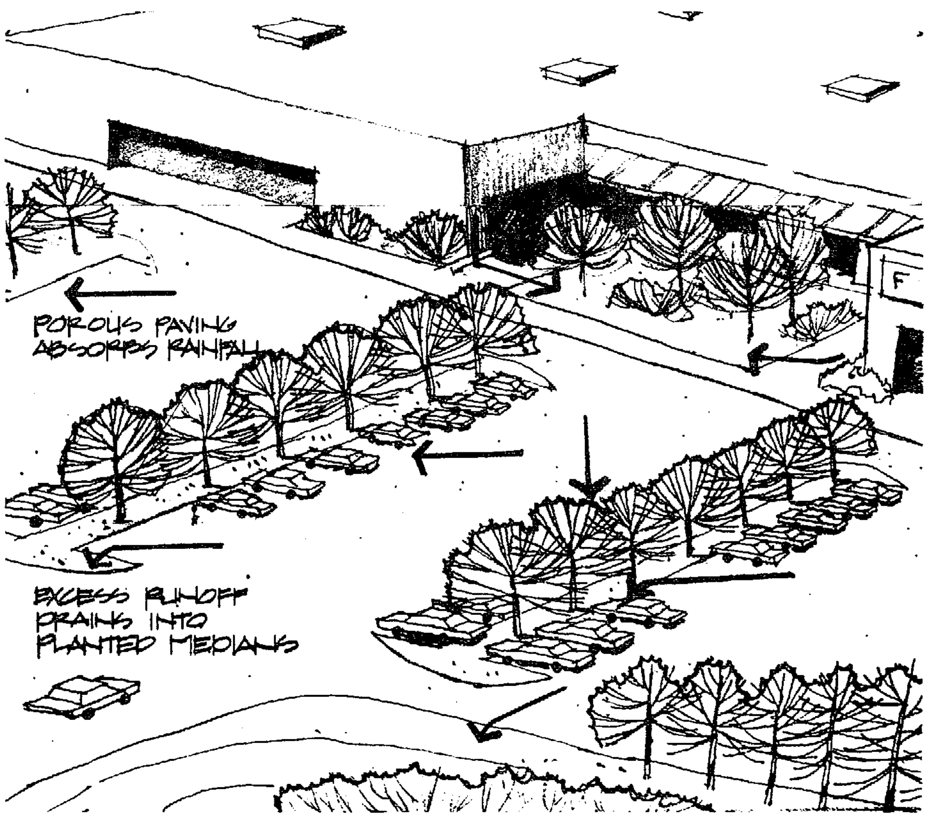
- **Dry wells,** pits filled with gravel or stone rubble and surrounded by a mesh soil separator or by a vertically set perforated fiberglass, concrete, or metal cylinder, can be used to collect stormwater from roof gutter downspouts. The water will be absorbed into the ground provided the soil is sufficiently permeable and unsaturated.
- **French drains,** perforated linear pipes set in a gravel trench, should be used to collect excess stormwater from the base of dry wells in areas where less permeable soils exist, and lead it into areas of greater soil permeability or to drainage outlets.

shopping centers and other large developments

Planners and developers are often faced with the difficult question of how to control the large amounts of runoff generated from shopping centers and other large developments and are often unaware of methods that can be used to increase on-site infiltration without cutting back on drainage efficiency.

Improved methods of controlling runoff can be found on the following pages.





Porous paving absorbs rainfall while runoff drains into planted medians, perimeter swales, and detention ponds.

the problems

Some of the problems of **flooding** in shopping centers and other large developments are the result of the natural permeability of the original soil giving way to **excessive amounts of impervious paved and building surfaces that are unable to absorb or retard the flow of stormwater.** With the **large amounts of runoff** that occur in commercial parking lots, roadways, walkways, and rooftops, any open land that can be retained and landscaped in their vicinity will help to balance runoff with positive infiltration.

the solutions

As with residential areas, the major objective of stormwater control for large developments is to allow for drainage away from the buildings and to hold some portion of runoff safely on-site until it can be absorbed by natural processes or slowly released to other drainage systems. This can be accomplished by proper site grading, increasing absorptive capacities, and detaining stormwater on-site. The use of porous paving, planted areas, detention ponds, and infiltration pits along the edge of parking lots and at the base of building walls, can increase the total absorptive capacity of the site. These features can reduce flood damages while providing an attractive environment for shoppers and other users.

improved grading

To limit the amount of sheet runoff causing local and downstream flooding, parking lots should be graded to direct runoff at a reasonable rate toward areas that can detain and either absorb or discharge rainwater slowly to other outlet points.

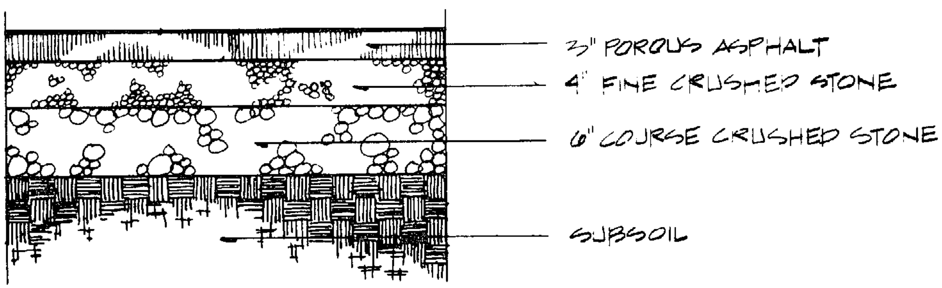
- The **gradient** of parking surfaces should not exceed two percent where feasible, to slow runoff and increase infiltration through the pavement pores. Where parking surfaces are forced into steeper slopes, flatter bands or landings should be graded at no more than 1 1/2-2%, at suitable intervals, to intercept flow and increase infiltration through the porous paving or other permeable material used.

- **Runoff** should be shed toward swales, perimeter ditches, medians, and other detention areas by proper grading design.

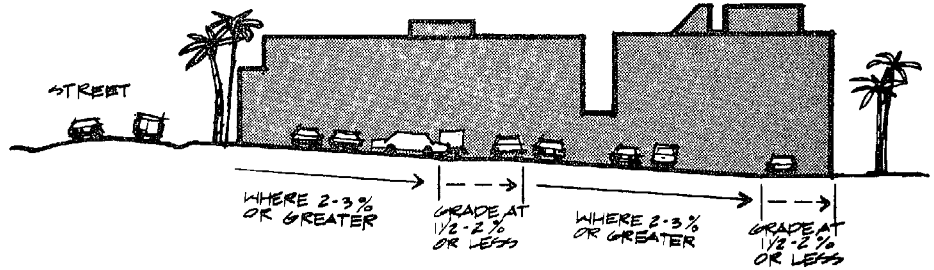
porous paving

In order to allow water to seep into subsurface soils, porous paving should be incorporated into existing sites and used on hard surfaced areas. Its ability to absorb and allow stormwater to percolate through will help to slow and reduce the amount of runoff.

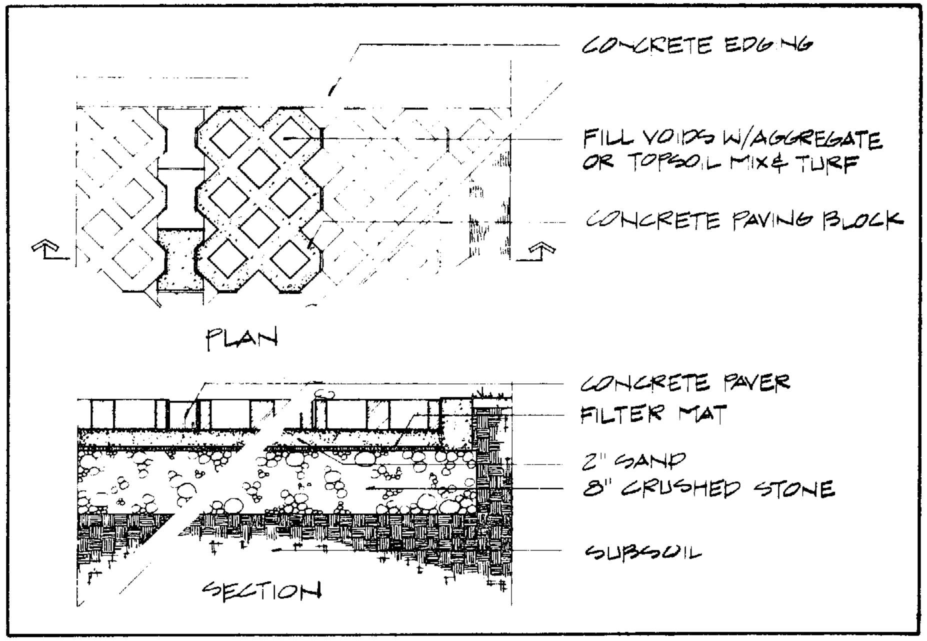
- **Popcorn paving** may be used on roads and parking surfaces especially where highly porous soils exist. Clogging of pores by silt and sand may occur over time, but may be reversed by vigorous hosing or by frequent vacuuming and sweeping. Where less permeable soil exists, borrowed porous fill from on- or off-site can be used in the grading process.
- **Aggregate paving,** such as crushed stone or sand, may also be used on pedestrian and on some vehicular surfaces.
- **Brick, interlocking,** and **lattice block pavers,** set on sand, as defined in the preceding residential section, may be used on pedestrian and parking areas among others for better absorption of stormwater.



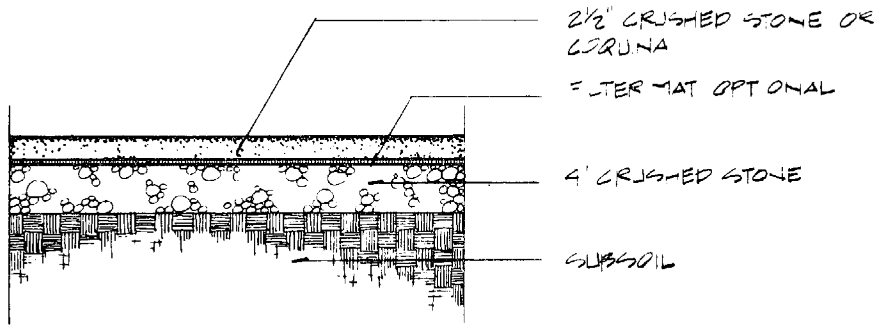
popcorn paving/porous asphalt



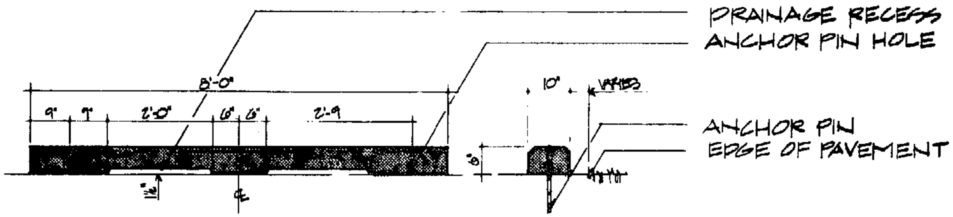
graded landings to increase infiltration in porous paving



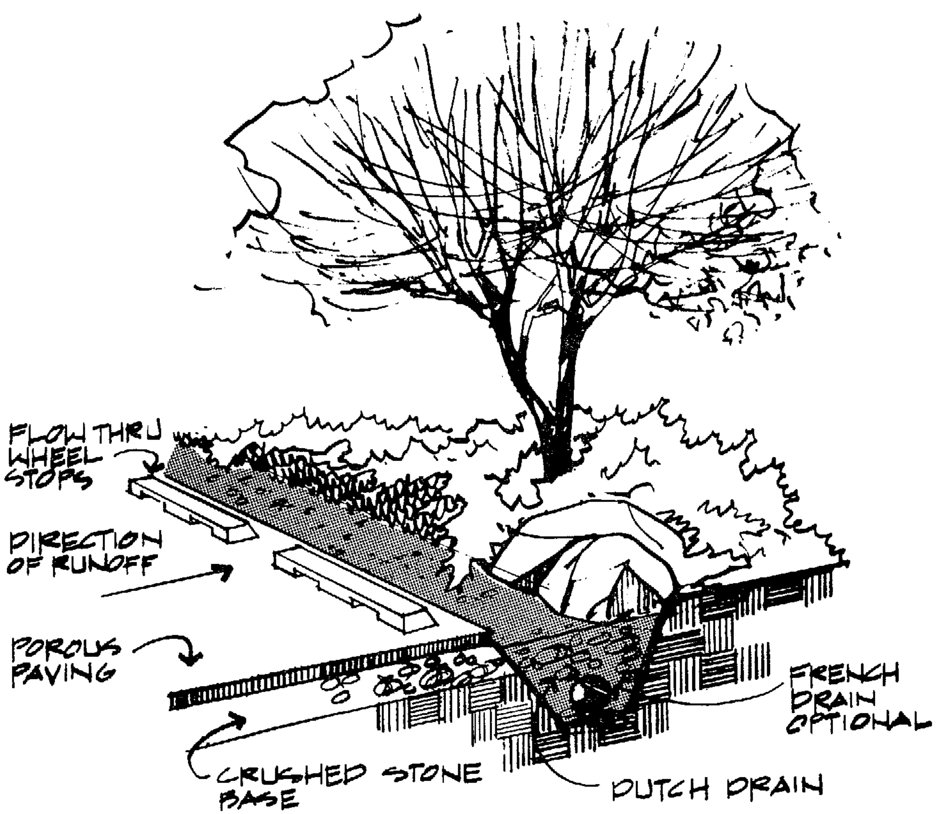
lattice block paving



aggregate paving surface



precast concrete wheelstops with runoff cuts



median strips intercept and absorb runoff

perforated wheel stops

Wheel stops are used to prevent vehicles from damaging median strips and other planted borders. They are typically precast in concrete and should have horizontal voids in their base for runoff flow.

perimeter ditches

A principal drainage channel should be located around shopping centers and other large developments to accept a portion of parking lot and roadway runoff while providing an opportunity for natural absorption and evaporation, and to carry excess runoff into an on-site detention pond where feasible.

- The **design** of perimeter ditches should follow that previously outlined in the agricultural land section.

median strips

Median strips should be designed to accept safe amounts of runoff from adjacent roadways and parking lots. Depending on their size they can incorporate plantings of species tolerant of temporary wet conditions and urban stormwater runoff, along with linear infiltration pits. Not only do median strips absorb stormwater runoff — passing excessive amounts on to other on-site outlet points — but they also filter out pollutants collected by runoff. Provision should be made through design to prevent vehicular leakages from reaching any sensitive plants in the median.

- The **size** of median strips should vary depending on planning requirements and the overall dimensions and requirements of each site.
- **Dutch drains,** linear ditches of gravel, should be used along the perimeter of medians to help intercept runoff, store it, and allow it to percolate into subsurface soils. Filter fabric should be used to separate gravel from the bordering soil to prevent clogging.

- **French drains,** perforated pipe surrounded by gravel, should be used to carry excessive stormwater from Dutch drains to on-site outlet points.
- **Sweeping and vacuuming** on roadways and parking lots should be performed on a regular basis to reduce clogging of pores caused by fine particles of soil and other debris.

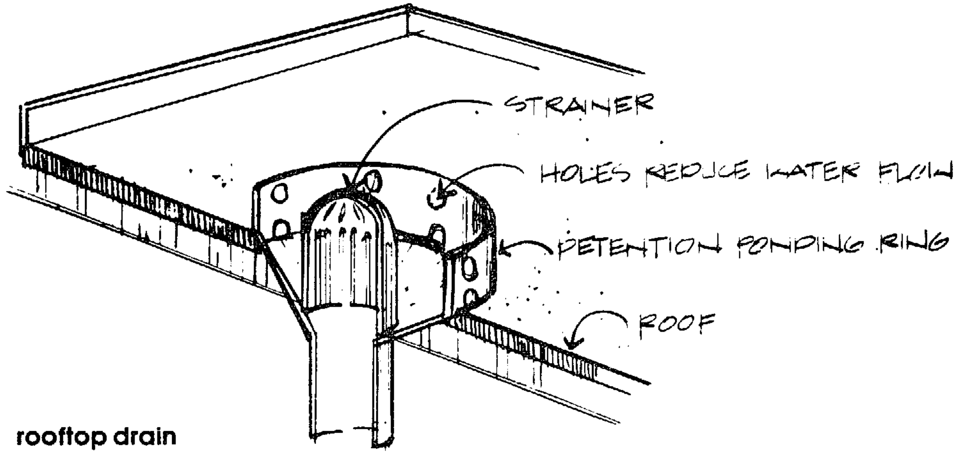
controlled roof drainage

Large rooftops can be designed to temporarily detain stormwater, reduce the total amount of runoff on ground surfaces, and allow collected stormwater to be absorbed by subsurface soils or passed on to other on-site detention points.

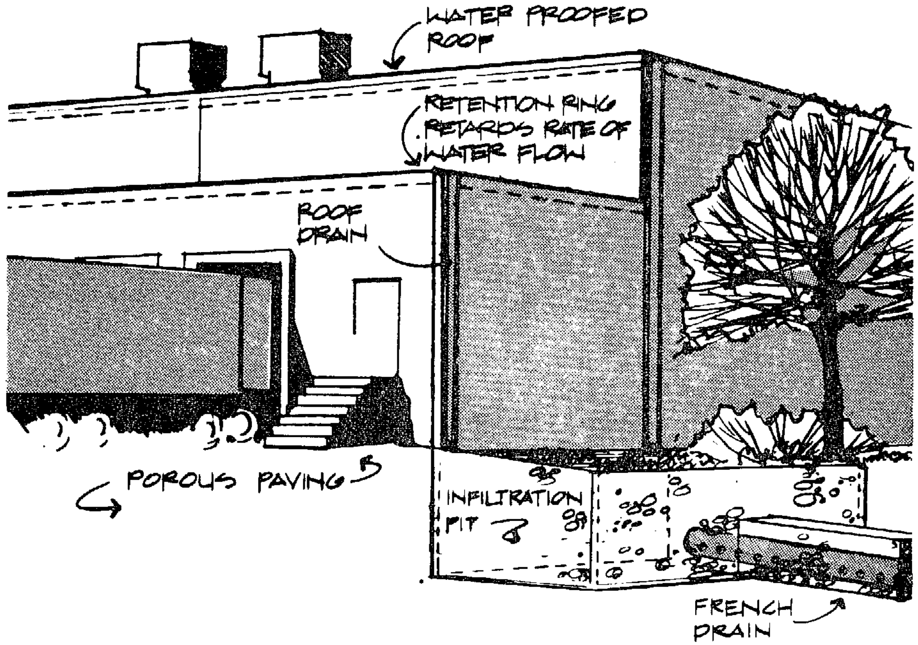
- **Rooftop drains** that utilize a strainer and detention ring to ensure a safe, moderated release of water into a drain pipe may be used.
- **Infiltration pits** dug into the ground directly below drain pipes and filled with gravel or porous rubble, should be installed to detain stormwater until it is absorbed by soil. Filter fabric should be used around gravel to keep out soil particles and other debris. Shrubs or other ground covers can be planted around the edges of infiltration pits to soften their appearance.

detention ponds

Detention ponds are intended to store excess on-site runoff collected from Dutch drains, French drains, swales, and perimeter ditches. During periods of moderate and high rainfall, detention ponds release excess amounts of stormwater into natural water courses or man-made systems. At other periods in time they allow for vegetative absorption, evaporation, and natural infiltration of detained water.



rooftop drain



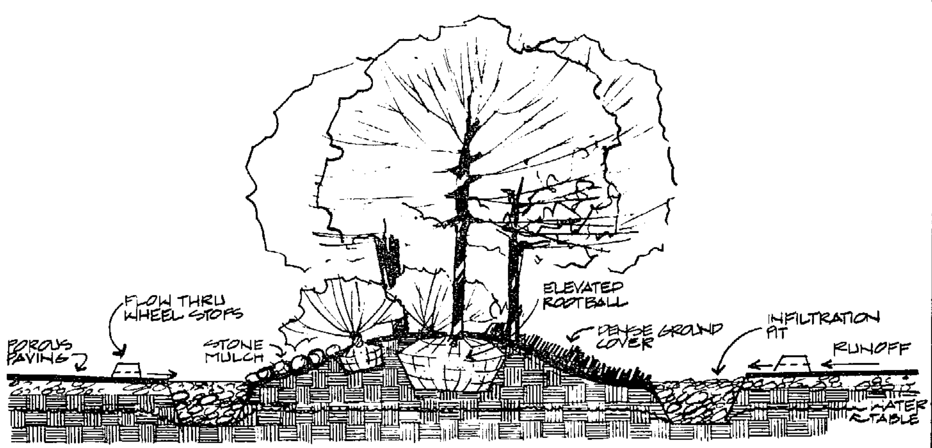
rooftop drainage system

- The **size and design** of detention ponds should not be determined by their stormwater control function alone, but with consideration given to their use as recreation areas, groundwater resuppliers, and aesthetic resources, among other functions.
- **Weirs** provide outlet of excess stormwater at pond edges and should be designed and set at a proper elevation by an engineer or other qualified professional. Weirs may also be arranged to hold back a higher head of water during storms than during fair weather and thus aid in flood control.

landscaping

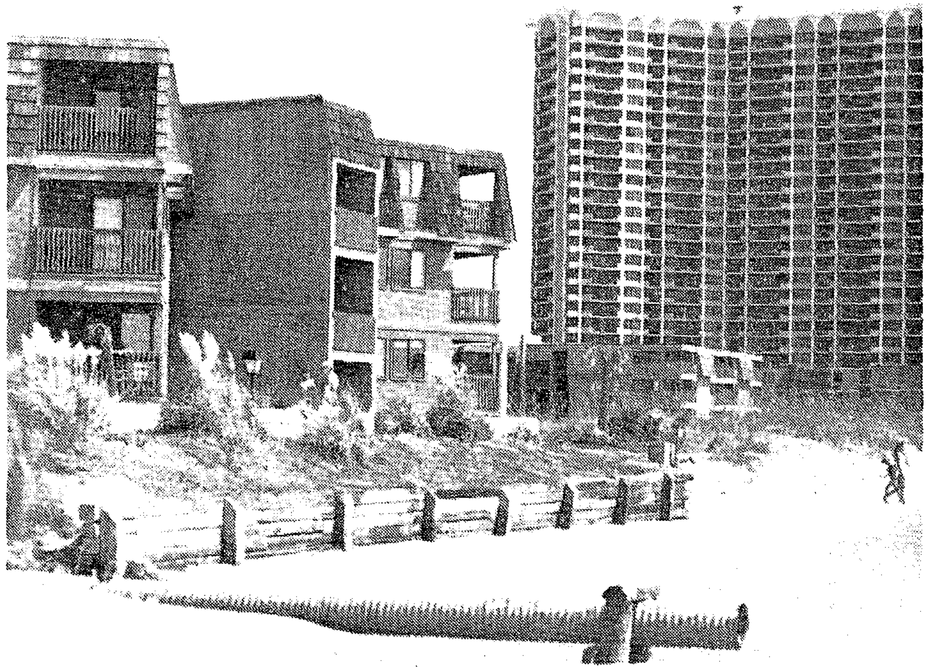
The use of native or ornamental trees, shrubs, and ground covers should be incorporated into shopping centers and other large developments not only for their visual benefits, as is oftentimes done, but to take advantage of their ability to control stormwater. A local landscape architect, nurseryman, or agricultural extension expert can recommend plants best adapted to site conditions.

- A **perimeter planting** of low grass should be used on gently sloping drainageway borders to stabilize bank soil. Grassing also helps to moderate fluctuations in ditch flow.
- **Dense vegetative ground covers** and **heavy mulches,** such as gravel, rocks, and shell hulls, may be used in planted median strips and areas where the soil is void of cover to prevent erosion.
- **Root zones** of median plantings should be slightly elevated by berming where standing water is likely to occur.
- **Invasive vegetation,** including types with intrusive root systems, should not be used in areas where they may cut down absorptive capabilities of French drains, infiltration pits, and other drainageways.



landscaping controls stormwater and improves aesthetic appearance.

shore areas



Development has taken place along the Grand Strand shoreline without respect to the sand dunes and their adjacent inland areas. Extensive erosion has occurred because of the lack of planning or poor design, and only recently have questions been asked on ways to reduce these adverse effects.

Modern methods for improving drainage by simulating natural processes can be found on the following pages.

the problems

the dynamic shoreline and the value of its dune system

The beaches, dunes, sand ridges, and swales that compose the Grand Strand's coastal edge are a dynamic and easily damaged component of the South Carolina coastal zone. Formed by a constantly changing regime of wind and water, sand dunes act as barriers, protecting the beach and inland areas from the erosive power of wind and waves. Stabilized by native vegetation such as Sea Oats, dunes are the primary shoreline defense against severe storms, high wave action, and strong winds. A stable, undisturbed dune system shelters the area immediately behind it. In a natural environment, this buffer protects the delicate ecological balances of the backshore and wetlands in their lee.

Dunes and the natural areas that occur behind them absorb and retain stormwater. When these areas are replaced with hard, impervious surfaces, such as parking lots, pool decks, patios, and rooftops, the stormwater that can no longer flow into the ground must be collected and disposed of. Often, as in Myrtle Beach, such drainage consists of stormwater pipes that discharge directly onto the beach. The result has been extensive erosion of the beach face, embankments, and pavement edges, all of which tend to accelerate natural beach erosion where it may exist, or change a stable beach into one susceptible to erosion. Correction of these problems generally requires drastic and expensive remedial action.

urban development and dune destruction

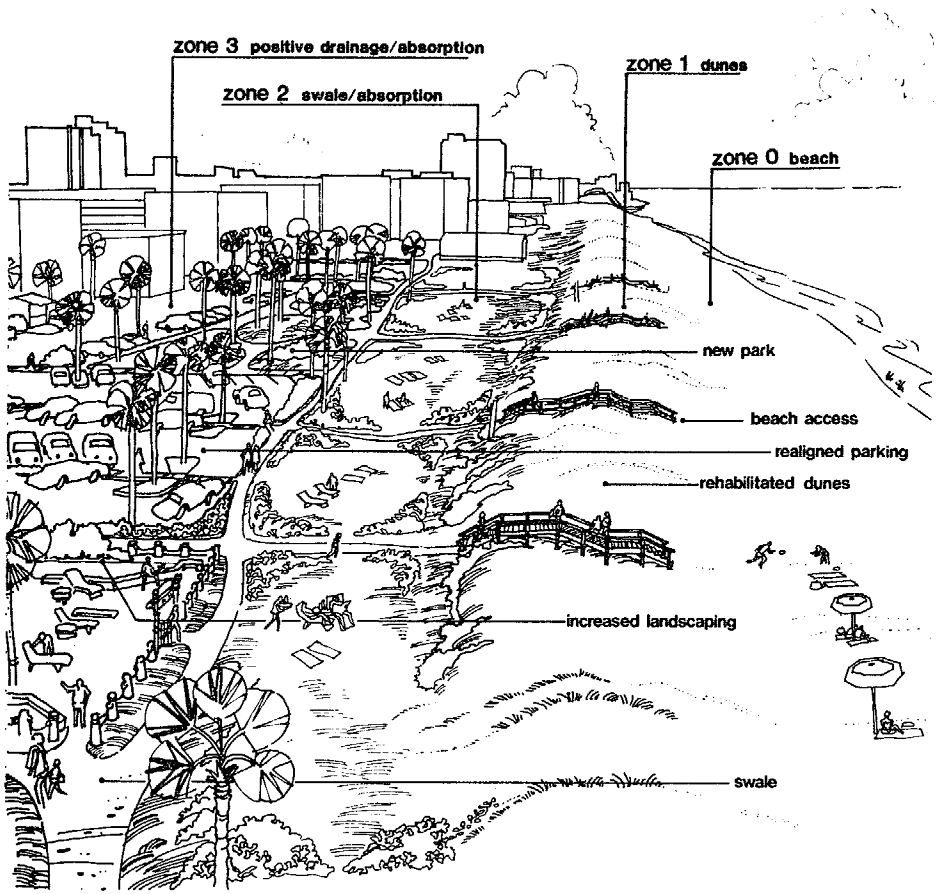
In developing areas, the dunes help buffer buildings, parking lots, lawns, and other site improvements against erosion and potentially destructive storms. If man is not careful in the planning, design, construction, and maintenance of areas that affect the dune zone, serious problems, many of which can be seen in Myrtle Beach, can develop. These problems, outlined below, can impose high reconstruction and maintenance costs on private landowners and perennial expenses on municipalities and other public bodies.

Three destructive mistakes are common along the sea edge of the Grand Strand:

- **removal of dunes**
- **construction of seawalls and other built edges as replacements to the dunes**
- **direct discharge of runoff via storm drains onto the beach face**

When dunes are removed, inland properties face a greater risk of danger from storm driven waves and winds unless a seawall or other vertical surface has replaced the dune. Seawalls and other vertical structures, however, can increase problems of beach erosion by reflecting wave energy that is normally absorbed by dunes, downward onto the beach, causing the breaking waters to scour and erode the beach. This scouring erosive action of waves decreases the beach width and leaves it more vulnerable to erosion. The removal of the dunes and narrowing of the beach area compromises the appearance and natural beauty of the shoreline, reducing the attractiveness of the beach to both residents and tourists.

The direct discharge of runoff via storm drains onto the beach causes deep eroded gullies to occur during periods of moderate and heavy rainfall; afterwards, standing water often occurs beneath these drain pipe outlets. Runoff from drain pipes and impervious hard surfaces not only deposits pollutants on the beach, but it also causes extensive erosion to the beach face and pavement edges and makes possible a greater "bite" by wave action. Pollutants and runoff from inland and adjacent shore areas cause the beach to become both visually and physically degraded and oftentimes requires costly repair and restoration efforts.



The beach (Zone 0 of the coastal edge) is vulnerable to erosion from both the sea and stormwater runoff. The dune line (Zone 1) can hold back and absorb surface runoff unabsorbed by the swale. The swale (Zone 2) provides for infiltration of runoff not absorbed by Zone 3 surfaces. Public and private parking areas, motels, street ends, and public walkways form the primary absorption zone (Zone 3). Existing surfaces in this zone should be redesigned to incorporate porous materials for parking, drives, and walks, along with extensive landscaping to provide for positive absorption of stormwater.

the solutions

By proper site selection, site planning, and design aimed at controlling runoff and minimizing erosion, developers can protect and enhance their investments in the dune environment. Owners of existing development can enhance the value of their properties and improve the appearance of their environment by altering the pattern of runoff.

Dunes, beaches, and all other elements of a coastline — whether natural or man-made — are subject to all the forces of the coastal environment. Before a municipality or a private landowner embarks on a dune reconstruction project, modifies seawalls, or begins a beach nourishment program, the expertise of coastal experts and knowledgeable officials, as well as the appropriate permits for beach modification, should be obtained.

build behind the dune zone

Sand dunes play an important role within the coastal community and provide protection to coastal development from wind, waves, and high tides.

- Where construction is yet to begin, **new residential or commercial structures should be sited behind the dune and swale zones** in the leeward protected area.
- **Structures should be located on the land so that dune stabilizing vegetation is left intact.** In this way, the dunes can continue to act in their natural role as protectors of lands to their lee, while leeward development can be sited to take advantage of the beauty and image of the dunes, as well as of views of the beach and ocean beyond.

landform modification

In sand flats leeward of the backdunes, where well-drained soils lie sufficiently above the water table, a greater opportunity for landform modification exists than is formed closer to the sea. As new communities developed in recent years have demonstrated, residential layouts with landforms modified into mounds and swales achieve good drainage and attractive residentail environments at the same time.

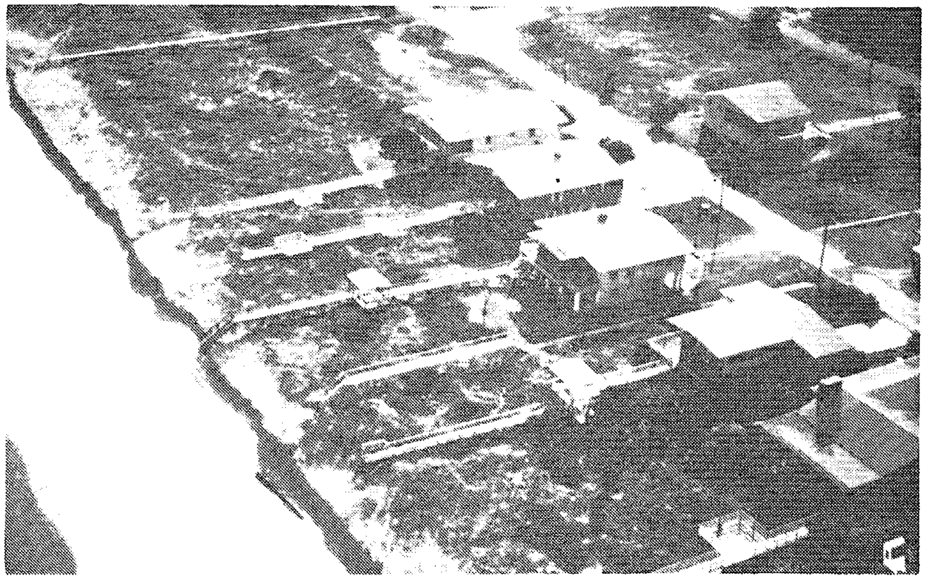
- **Pond** and **swale** excavation material should be graded into broad mounds or other natural appearing landforms to elevate houses and their adjacent grounds.
- **Mounds** and **swales** should be laid out consistent with the overall drainage plan of the site, allowing water to move off the land at a restrained, non-erosive rate.
- **Suitable grasses** should be planted over exposed sand surfaces after landform modifications have been completed.

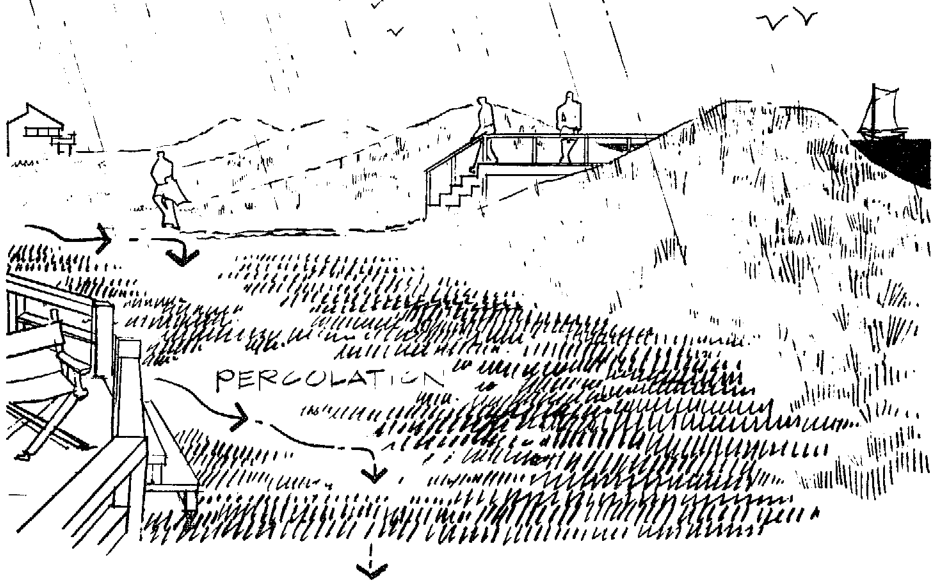
avoid obstruction to estuarine flow

The construction of causeways or the placement of landfill in salt marshes or waters can adversely affect the subtle and varied circulation patterns that are critical to providing nutrients to aquatic and intertidal organisms through the food web to coastal fish and wildlife.

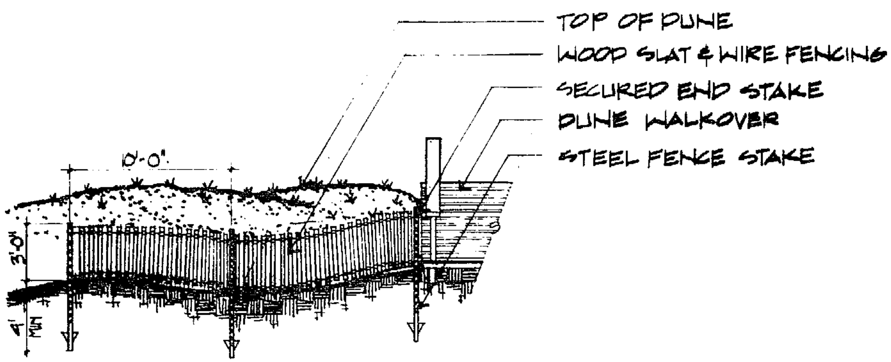
By slowing the velocity of tidal flow, causeways and other fill typically cause increased sedimentation and yet further loss of ecological systems, not to speak of lost navigation capacity and increased dredging costs.

- **Pilings** or other substructures should be used to elevate roadways in order to allow the continuity of natural tidal flow patterns.
- **Fill** should never be placed in wetlands, which are among the most valuable biologically productive resources we possess.

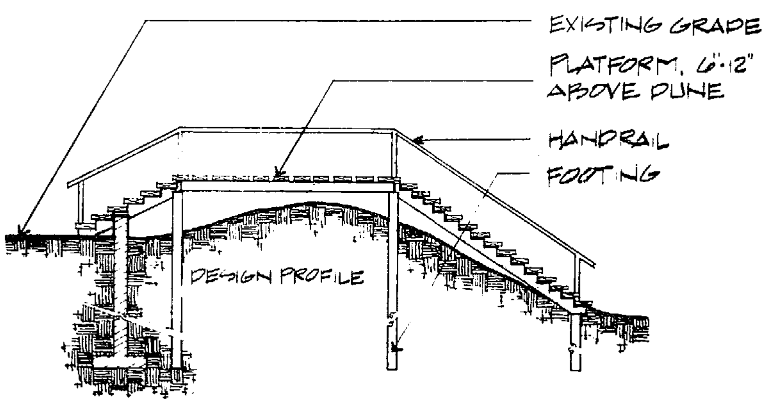




grassed swale absorbs stormwater



dune fence



dune walkover

dune reconstruction

By limiting development to the leeward side of the dune zone, seawalls and other beachfront protection structures may not be necessary. Where dunes have been removed or seawalls already exist, the remnant dune may be reconstructed to renaturalize the appearance of the beach and afford some storm protection. Sand can be bermed up against a seawall, where one has been built, and may be partially stabilized by native vegetation and dune fencing. In some areas, sand nourishment may be feasible as a means of restoring beaches. Where this is possible, reconstructed dunes will be afforded added protection from the sea.

If beach conditions allow dune reconstruction, the following steps can be followed.

- **Place sand** to a height of three to four feet to establish the dune base.
- **Plant suitable vegetation** such as Sea Oats **(Uniola paniculata),** Bitter Panicum **(Panicum amarum),** and other suitable species. Experts should be consulted before planting to determine site specific suitabilities for particular species.
- **Dune fencing** should be installed just behind the beach toe of the dune to encourage the deposition of more sand by the wind. A line of dune fence should also be installed on the backside of the dune to prevent trampling and erosion by beachgoers. This fence will also help trap windblown sand. (A fence is also typically set along the dune ridge where the dune base is broader than fifty feet.)
- **Dune walkovers** should be constructed to allow people access to the beach and minimize trampling of the reestablished dune.

conclusions

The use of most land within the Waccamaw region is highly dependent on adequate drainage. If land resources are to be more wisely managed, protected, or developed, improved measures to control flooding, erosion, and sedimentation must be put into practice. For much, if not all, development within the region there are ways to design the land, improve site drainage, enhance property value, reduce public and private expense, and decrease impact on natural areas.

Through improved site and land design, together with local and county storm water runoff management, supported by both ordinances and voluntary cooperation at both levels, improved drainage and runoff control are achievable. If the objectives can be achieved, Georgetown, Horry and Williamsburg Counties may enjoy new benefits and lowered costs through the years to come.

1 minimized erosion and sedimentation

Proper ditch design, spoil handling, farm equipment turns, ditch slope grassing and maintenance, curved swale and mound design, detention pond development, replacement of impervious surfaces with permeable paving, and retaining large areas of landscaping and other high-infiltration surfaces can all go far to improve both on-site and off-site drainage. With improvement, houses and other structures set upon the higher ground of graded earth mounds will be better protected from stormwater. At the same time, there will be less erosion and sedimentation of drainageways and less flooding from filled ditches.

2 improved water quality

By building homes and septic systems on raised earth to secure satisfactory heights above groundwater, we may be able to decrease chances that septic leachate will reach and pollute water supplies and recreational water bodies. The slowing down of rapid runoff can also improve water quality in rivers, ponds, and estuaries by reducing erosion and siltation.

3 protected ecosystems

By limiting erosion and sediment loads in drainageways, the problems of siltation and filling in of wetlands, waterways, and estuarine waters can be reduced. Proper drainage control can thus result in improved environmental quality and help protect fragile ecosystems and the valuable fisheries and wildlife species they support.

4 minimized public and private costs

By employing techniques outlined in this handbook, home and other property owners can limit the expense they incur from the costs associated with clean-up, repair, and replacement of flood damaged features. Costs to municipal, county, and state government for flood clean-up, ditch maintenance, and pipe and ditch installation can be reduced. The cost of dredging navigable waters to remove sediments can be lowered. Similarly, on agricultural lands, a reduction of back-up flooding will decrease crop damage and loss of revenue to the farmer.

5 improved appearance

By molding landforms and carving meandering swales, mounds, retention ponds, and other landscape elements, we can make residential and commercial areas more attractive. The Waccamaw region is a good place to live, and its landscape can be not only protected, but enhanced by the simple measures discussed in this handbook.

6 enhanced property values

The improved appearance and reduced potential for flooding and wet conditions can serve to increase property values and the marketability of new developments.

... notes

glossary

berm low mound of earth used to alter runoff direction

coastal plain the relatively flat coastal region that lies between the Piedmont and the ocean shore

culvert drainageway extending beneath a roadway, driveway, or embankment

erosion process by which rainfall or wind suspends and transports soil particles

groundwater subsurface water in a zone of permanently saturated soil beneath the water table

gumbo heavy, clayey soil with low permeability

hydrology circulation of water on the surface layers of the earth and through the atmosphere

impervious not permitting the infiltration of water

marsh wet, periodically flooded area mainly covered by grasses

percolation movement of water downward through the upper soil surfaces to the water table

permeable permitting the infiltration of water

sedimentation or siltation the deposition of fine soil or sand particles by water

spoil excavated soil or rock

surcharge a flow of water that exceeds the capacity of the channel carrying it

water table uppermost limit of water-saturated subsurface soils

weir a barrier in a drainageway or detention pond designed to maintain the water level at a specified height

for further assistance

For further information on ways in which you can help minimize drainage problems, please contact:

- Waccamaw Regional Planning and Development Council
  1001 Front Street
  Georgetown, S.C. 29440
  (803) 546-8502

In Georgetown County:

- Soil Conservation Service
  P.O. Box 606
  Georgetown, S.C. 29440
  (803) 546-7808
- Clemson University Agricultural Extension Service
  P.O. Box 1100
  Georgetown, S.C. 29440
  (803) 546-4481, 546-6421

In Horry County:

- Soil Conservation Service
  P.O. Box 500
  Conway, S.C. 29526
  (803) 248-9118
- Clemson University Agricultural Extension Service
  P.O. Box 967
  Conway, S.C. 29526
  (803) 248-2267

In Williamsburg County:

- Soil Conservation Service
  P.O. Box 30
  Kingstree, S.C. 29556
  (803) 354-9621
- Clemson University Agricultural Extension Service
  Courthouse Square
  Kingstree, S.C. 29556
  (803) 354-6106

suggested reading

Georgia Department of Natural Resources, **Handbook: Building in the Coastal Environment,** 1975

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